THE ART OF BUILDING IN THE CLASSICAL WORLD

VISION, CRAFTSMANSHIP, AND LINEAR PERSPECTIVE IN GREEK AND ROMAN ARCHITECTURE

JOHN R. SENSENEY

CAMBRIDGE

CAMBRIDGE www.cambridge.org/9781107002357

This page intentionally left blank

THE ART OF BUILDING IN THE CLASSICAL WORLD

This book examines the application of drawing in the creation of classical architecture, exploring how the tools and techniques of drawing developed for architecture subsequently shaped theories of vision and representations of the universe in science and philosophy. Building on recent scholarship that examines and reconstructs the design process of classical architecture, John R. Senseney focuses on technical drawing in the building trade as a model for the expression of visual order, showing that the techniques of ancient Greek drawing actively determined concepts about the world. He argues that the uniquely Greek innovations of graphic construction determined principles that shaped the massing, special qualities, and refinements of buildings and the manner in which order itself was envisioned.

John R. Senseney is Assistant Professor of the History of Ancient Architecture in the School of Architecture at the University of Illinois at Urbana–Champaign. A historian of ancient Greek and Roman art and architecture, his current and forthcoming articles and chapters appear in *Hesperia*, the *Journal of the Society of Architectural Historians*, the *International Journal of the Book*, *The Blackwell Companion to Roman Architecture* (edited by Roger Ulrich and Caroline Quenemoen), and *Sacred Landscapes in Anatolia and Neighboring Regions* (edited by Charles Gates, Jacques Morin, and Thomas Zimmermann).

THE ART OF BUILDING IN THE CLASSICAL WORLD

Vision, Craftsmanship, and Linear Perspective in Greek and Roman Architecture

John R. Senseney
University of Illinois at Urbana–Champaign

CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town,
Singapore, São Paulo, Delhi, Tokyo, Mexico City

Cambridge University Press
32 Avenue of the Americas, New York, NY 10013-2473, USA

www.cambridge.org
Information on this title: www.cambridge.org/9781107002357

© John R. Senseney 2011

This publication is in copyright. Subject to statutory exception
and to the provisions of relevant collective licensing agreements,
no reproduction of any part may take place without the written
permission of Cambridge University Press.

First published 2011

Printed in the United States of America

A catalog record for this publication is available from the British Library.

Library of Congress Cataloging in Publication data

Senseney, John R. (John Robert), 1969–
The Art of Building in the Classical World: Vision, Craftsmanship, and Linear
Perspective in Greek and Roman Architecture / John R. Senseney.
p. cm.
Includes bibliographical references and index.
ISBN 978-1-107-00235-7
1. Architectural design. 2. Architectural drawing. 3. Architecture, Classical. I. Title.
NA2750.S45 2011
722′.8–dc22 2010049728

ISBN 978-1-107-00235-7 Hardback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs
for external or third-party Internet Web sites referred to in this publication and does not
guarantee that any content on such Web sites is, or will remain, accurate or appropriate.

To Megan, with much of a muchness

CONTENTS

List of Figures *page* ix
Preface xi
Note on Dates and Translations xiii
Abbreviations xv

INTRODUCTION: CHALLENGES OF ANALYSIS AND INTERPRETATION 1

1 THE IDEAS OF ARCHITECTURE 26

2 VISION AND SPATIAL REPRESENTATION 60

3 THE GENESIS OF SCALE DRAWING AND LINEAR PERSPECTIVE 104

4 ARCHITECTURAL VISION 142

Excursus: Envisioning Cosmic Mechanism in Plato and Vitruvius 175
Appendix A Analysis of the Dimensions of the Blueprint for Entasis at Didyma 189
Appendix B Analysis of the Hypothetical Working Drawing for Platform Curvature at Segesta 191
Appendix C Analysis of the Hypothetical Working Drawing for Platform Curvature in the Parthenon 192
Notes 195
References 227
Index 241

LIST OF FIGURES

1. Pantheon, Rome. A.D. 120s, 2
2. Classical Parthenon, Athens. 447–438 B.C., 3
3. Myron of Athens (fifth century B.C.). Diskobolos (Lancellotti Discobolus), 5
4. Myron of Athens (fifth century B.C.). Diskobolos (Lancellotti Discobolus), 6
5. Horse and jockey. Hellenistic, ca. 150–125 B.C., 7
6. Sleeping hermaphrodite. Antonine copy (A.D. 138–192) of a Hellenistic original of the second century B.C., 7
7. Hellenistic Didymaion, 12
8. Hellenistic Didymaion, 13
9. Hellenistic Didymaion, 13
10. Hellenistic Didymaion, 15
11. Leonardo da Vinci (1452–1519). The "Vitruvian Man," 20
12. Theater of Dionysos, Athens, 21
13. Forum of Caesar, Rome, 24
14. Whole-number ratios used in Greek temple buildings of the Classical period, 27
15. Temple of Juno Lacinia, Agrigento, 28
16. Temple of Concordia, Agrigento, 29
17. Temple at Segesta, 30
18. Hephaisteion, Athens, 30
19. Hephaisteion, Athens, 31
20. Parthenon, Athens, 32
21. Parthenon, Athens, 33
22. Anta Building, Didyma and East Building, Didyma, 35
23. Hermogenes (third and second centuries B.C.). Temple of Artemis Leukophryne at Magnesia-on-the-Maeander, 37
24. Archaic Parthenon, Athens. Modified from M. Korres, 39
25. Akropolis, Athens, 40
26. Schematic comparison of typical plans of Doric hexastyle and Ionic octastyle temples with the Parthenon, 41
27. Parthenon, Athens, 42
28. Parthenon, Athens, 43
29. Temple of Athena, Paestum (ancient Greek Poseidonia), 46
30. The symbol of the tetraktys, 46
31. Temple A, Asklepieion, Kos, 47
32. Temple A, Asklepieion, Kos, 48
33. Hellenistic Didymaion, 49
34. Diagram for Euclid's proof of a geocentric universe, 61
35. The zodiac as a circular construction with twelve equal sectors for the signs, 66
36. The revolving cosmos according to the model of Eudoxos, 67
37. The zodiac as a twenty-four-part construction, 69
38. Tholos on the Marmaria terrace, Sanctuary of Athena Pronaia, Delphi, 70
39. Tholos at the Asklepieion, Epidauros, 71
40. Round Temple, Rome, ca. 100 B.C., 72
41. The Latin Theater as described by Vitruvius, 73

42. The six-petal rosette, 76
43. Diagram of Aristoxenos (fourth century B.C.) for the placements of sounding vessels in the theater, 77
44. Circuits of the revolutions of the moon, sun, and planets through the zodiac, 78
45. Markets of Trajan, Rome, 79
46. Theater, Asklepieion, Epidauros, 80
47. Theater, Asklepieion, Epidauros, 81
48. Theater, Akropolis, Pergamon, 81
49. The Greek theater, according to Vitruvius, 82
50. Lower theater at Knidos. Modified from I.C. Love, 83
51. Diagrams of Greek theaters with their geometric underpinnings, 84
52. Diagrams of Greek theaters with their geometric underpinnings, 85
53. Theater at Priene, 87
54. Hypothetical Greek protractor or "curved ruler" indicating angular divisions of 15 degrees, 91
55. Pnyx, Athens, phase III, 96
56. Pnyx, Athens, phase III, 97
57. Graphic form of the analemma as described by Vitruvius, 101
58. Hellenistic Didymaion, 105
59. Hellenistic Didymaion, 105
60. Hellenistic Didymaion, 107
61. Temple at Segesta, 109
62. Hellenistic Didymaion. Modified from L. Haselberger, 111
63. Parthenon, Athens, 115
64. Proposed graphic constructions for platform curvature on the northern flanks of the temple at Segesta and the Parthenon, 117
65. Archaic Didymaion. Restored capital, 118
66. Hellenistic Didymaion, 119
67. Stoa, Agora, Kos. Unfinished Ionic column drum preserving the radial construction for the fluting of its Ionic columns, 120
68. Artemision, Sardis. Detail of column, 121
69. Hellenistic Didymaion, 122
70. Hellenistic Didymaion, 123
71. Proposed sequence for fluting drums at the Hellenistic Didymaion according to analysis of blueprint, 124
72. "Rosette-based" method for determining fluting on a blueprint like that at Didyma, 125
73. Hellenistic Didymaion. Pit on surface of the north adyton wall of the Didymaion, 126
74. Hellenistic Didymaion. Blueprint for column fluting, 126
75. Hypothetical methods of producing twenty equal divisions of circumference for Doric fluting, 127
76. Hypothetical methods of fluting columns using a protractor, 131
77. The zodiac as a circular construction with twelve equal sectors for the signs; the Greek theater according to Vitruvius, 133
78. Artemision and agora, Magnesia-on-the-Maeander, 140
79. Human form defined by sample modules, proportions, and geometry, as described by Vitruvius, 145
80. Temple of Athena Polias, Priene. Restored drawing of a cornice and pediment incised into a block built into the temple, 154
81. Temple of Athena Polias at Priene by Pytheos and Temple of Artemis Leukophryne at Magnesia-on-the-Maeander by Hermogenes, 155
82. Temple of Athena Polias, Priene, 157
83. Temple of Dionysos at Teos, 159
84. Asklepieion, Kos, 162
85. Upper Terrace with Temple A, Asklepieion, Kos, 163
86. Temple A, Asklepieion, Kos, 163
87. Sanctuary of Juno, Gabii, 164
88. Temple of Juno, Gabii, ca. 160 B.C., 165
89. Temple of Juno, Gabii, 166
90. Sanctuary of Aphrodite, Kos, 167
91. Severan Marble Plan fragments showing the Porticus Octaviae (Porticus Metelli, renamed and rebuilt under Augustus), Rome, overlaying modern urban features, 168
92. Porticus Metelli (later Porticus Octaviae), Rome, 169
93. Forum of Trajan, Rome, 171
94. Octagon of Nero's Golden House on the Esquiline Hill in Rome, 173
95. Pantheon, Rome, 174

PREFACE

This book examines the importance of Greek building and thought for the creation of architecture as Vitruvius understood it in a Roman context. In focusing on the central role of Greek practices of scale drawing and linear perspective, it considers the influence that Roman architecture drew on from Greek architects and concepts of craftsmanship. More than this, however, I explore the impact of the instruments and techniques of Greek architects on the classical understanding of the forms and mechanisms of nature and how the eye perceives them. Rather than demonstrating how classical architecture merely reflects the features of its larger cultural context, I try to show how the practices of Greek architects actively determined concepts about the world. In addition to classicists and historians of art and architecture, therefore, this book addresses readers interested in the history of philosophy and science, as well as architects who draw inspiration from the classical world.

In acknowledging only a small share of those directly involved with the realization of this work, I want to first thank my mentor, Fikret K. Yegül, who, in addition to training me in ancient art and architecture, read this book's manuscript in its entirety. His expertise allowed for the comments, criticisms, and insights necessary to elevate it above the artlessness of its first draft. Credit for the merits of this project must go to Beatrice Rehl, Publishing Director of Humanities and Social Sciences at Cambridge University Press. Beatrice's editorial assistant, Amanda Smith, provided invaluable help in the realization of this book. My wife, Megan Finn Senseney, read and edited later drafts of the manuscript, enhancing it with her gift for language and her command of sources as a real information scientist. I would also like to express gratitude to the particularly thoughtful anonymous reviewers of my manuscript, who provided encouragement and much needed perspectives on both details and larger issues. Architects Sarang Gokhale and Erin Haglund offered excellent assistance with my line drawings that illustrate many of the arguments of this book.

At various stages, the ideas of this book benefited from conversations with several classicists and historians of art and architecture. James and Christina Dengate were always generous with their enthusiasm, feedback, and sharing of sources. Diane Favro challenged my ideas with incisive questions. Erich Gruen took the time to meet with me and offer his ideas on the Hellenistic and Roman historical contexts of my research on ancient architecture. Richard Mohr offered invaluable feedback on my interest in Plato. Robin Rhodes generously discussed the details of my research and invited me to join his panel exploring the subject of scale in Greek architecture. David Sansone gave important feedback on my interest in Aristophanes. Phil Sapirstein provided enlightening thoughts and questions about the technology of building and design, particularly in the Archaic period. Both in person and via email, Andrew Stewart asked me penetrating questions about my developing research in Greek architectural drawing, which resulted in several of the paths I later took in this book. Phil Stinson gave me his thoughts and encouragement on a variety of topics. I have also benefited from my colleagues researching the topic of historical architectural drawing in later periods, including Robert Bork, Anthony Gerbino, Raffaela Fabbiani Giannetto, Ann Huppert, and Heather Hyde Minor. In addition to Heather Hyde Minor, this study simply would not have been possible without the incredible support of my colleagues Dianne Harris and Areli Marina. Finally, the ideas and approaches in the book build on a foundation in art history shaped by my amazing teachers, C. Edson Armi and Larry Ayres. Any mistakes of fact or questionable interpretations in the final work result from my own divergence from the helpful suggestions of these excellent scholars.

Concepts also developed from the help of several friends and family members, including Jonathan Banks, Brent Capriotti, Heidi Capriotti, Barbara Cohen, Lawrence Hamlin, Dan Korman, Geza Kotha, Paolo Maddaloni, Rick Mercatoris, Madhu Parthasarathy, Donna Senseney, Megan Finn Senseney, Debbie Senseney-Kotha, Kevin Serra, Leonore Smith, Smitha Vishveshwara, and many others.

Lastly, the following awards provided indispensable support for the research and writing of this book: A William and Flora Hewlett International Research Travel Grant; funding for travel, research assistantships, a partial release from teaching, and image reproduction rights from the Campus Research Board of the University of Illinois at Urbana–Champaign; travel funding from the Laing Endowment of the School of Architecture at the University of Illinois at Urbana–Champaign; and travel funding from two separate Creative Research Awards of the College of Fine and Applied Arts of the University of Illinois at Urbana–Champaign.

John R. Senseney
Heraklion, May 2010

NOTE ON DATES AND TRANSLATIONS

All dates are B.C. unless specified as A.D. or given in obvious post-antique contexts like the Renaissance. Classical with a capital "C" indicates the Classical period of ancient Greece specifically (479–323 B.C.), whereas classical with a lowercase "c" more generally describes Greek and Roman antiquity.

An exact or even relative chronology of the works of Plato (ca. 427–347 B.C.) is perhaps impossible to establish with any certainty. For the purposes of the present study, it will suffice to recognize Plato as a writer of the Late Classical period in the early to mid-fourth century B.C., and to follow the unquestionable chronological order of the *Republic* before the *Timaeus*.

Unless otherwise indicated, quotations from primary sources are given in the author's translation.

ABBREVIATIONS

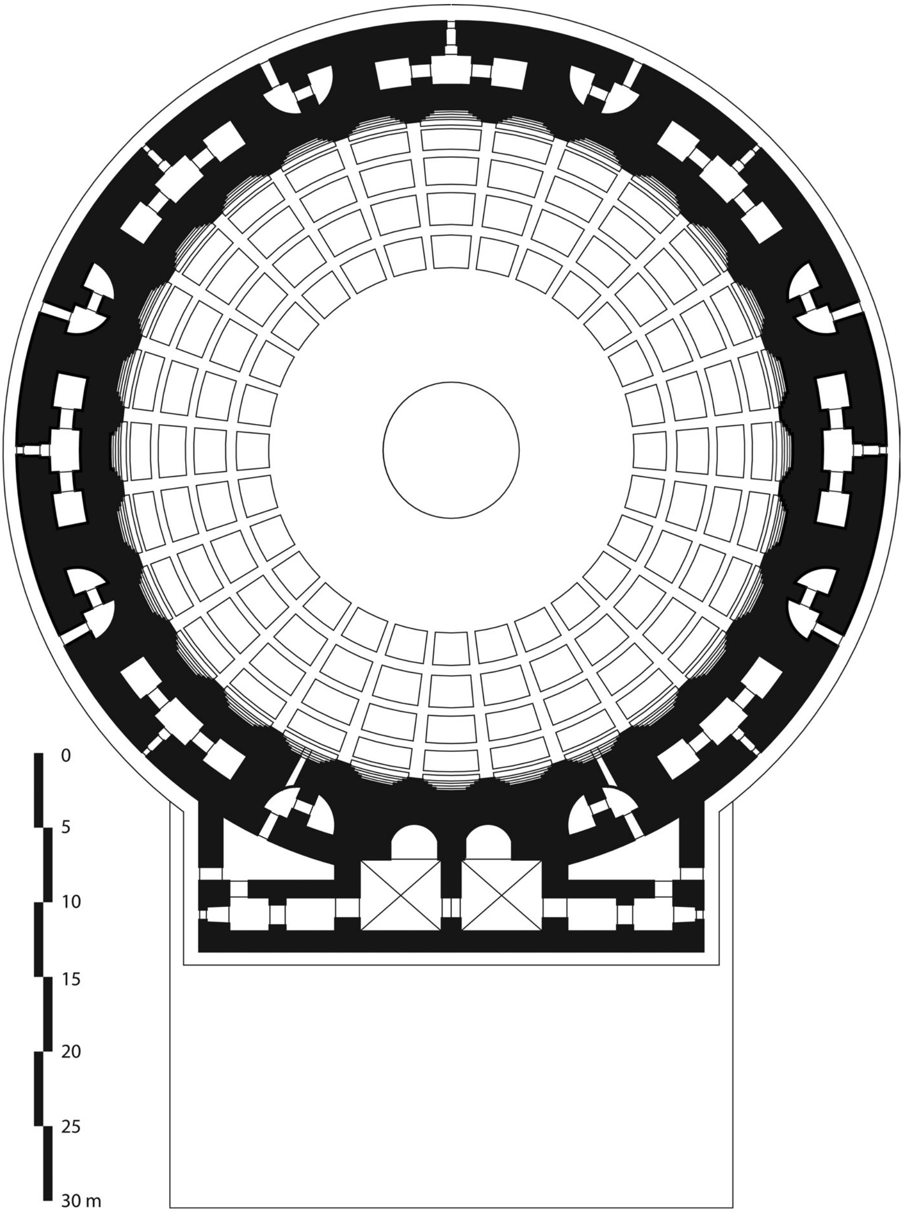
Abbreviations not specified in this section follow the standard abbreviations set forth in the *American Journal of Archaeology*.

Bauplanung	Deutsches Archäologisches Institut, ed. (no date). *Bauplanung und Bautheorie der Antike. Bericht über ein Kolloquium veranstaltet vom Architekturreferat des Deutschen Archäologischen Instituts (DAI) mit Unterstützung der Stiftung Volkswagenwerk in Berlin vom 16.11 bis 18.11.1983*. Berlin.
Gabii	Almagro-Gorbea, M., ed. 1982. *El Santuario del Juno en Gabii*. Biblioteca Italica 17. Rome.
Hermogenes	Hoepfner, W., ed. 1990. *Hermogenes und die hochhellenistiche Architektur. Internationales Kolloquium in Berlin vom 28. bis 29. Juli 1988 im Rahmen des XIII. Internationalen Kongresses für Klassische Archäologie veranstaltet vom Architekturreferat des DAI in Zusammenarbeit mit dem Seminar für Klassische Archäologie der Freien Universität Berlin*. Mainz am Rhein.
Küstlerlexikon	Vollkommer, R., ed. 2001. *Küstlerlexikon der Antike*. Munich and Leipzig.
Parthenon	Neils, J., ed. 2005. *The Parthenon: From Antiquity to the Present*. Cambridge.
Refinements	Haselberger, L. 1999. *Appearance and Essence. Refinements of Classical Architecture: Curvature. Proceedings of the Second Williams Symposium on Classical Architecture held at the University of Pennsylvania, Philadelphia, April 2–4, 1993*. Philadelphia.
Vitruvius	Geertman, H. and J.J. de Jong, eds. 1989. *Munus non ingratum: Proceedings of the International Symposium on Vitruvius' De architectura and Hellenistic and Republican Architecture = BABesch*, supp. 2. Leiden.

INTRODUCTION: CHALLENGES OF ANALYSIS AND INTERPRETATION

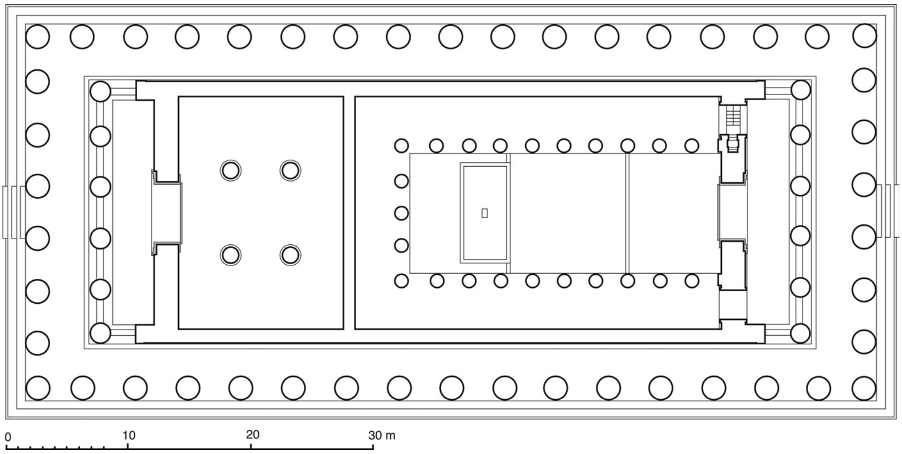
When Renaissance architects like Bramante or Alberti executed or wrote about linear perspective and scale architectural drawings, they engaged in practices and discourses that were already well established by the time Vitruvius picked up his pen near the end of the first millennium B.C.[1] In addition to what Vitruvius tells us about the subject, there are other Roman references to scale drawings used in architectural planning,[2] as well as a few surviving examples that can hardly attest to the frequency with which such drawings surely must have been made.[3] More than just a fact of the design process, the application of geometry in scale drawings during the Imperial era in particular may have engendered the very aesthetic based on the curve and polygon that characterizes Roman vaulted buildings perhaps as best appreciated today in the Pantheon (Figure 1).

This observation, which is far from new, underscores the formative role of reduced-scale drawing not only in the creation of buildings, but also in the guiding approaches to form that underlie their production.[4] In a straightforward emphasis on technical determinism, one may view the fluid, plastic potential of Roman concrete as the primary impetus that transcended the prismatic forms determined by traditional Greek construction with rectilinear blocks.[5] Yet keeping in mind the additional importance of the curvilinear, radial, and polygonal qualities of classical scale drawings, one may perhaps better understand Roman concrete as the material exploited to reflect in three dimensions the forms first explored in ichnography (the art of ground plans), elevation drawing, and linear perspective.[6] Acknowlement of this generative aspect of ancient drawings emphasizes their function as models rather than mere architectural representations.[7]



1 Pantheon, Rome. A.D. 120s. Plan of level III showing radial pattern of intrados. Drawing author, adapted from B.M. Boyle, D. Scutt, R. Larason Guthrie, and D. Thorbeck, in MacDonald 1982: Plate 103.

Of course, the idea that scale drawing precedes building should hardly sound revolutionary. At least until recently, architectural students commonly learned to conceive of buildings in terms of *parti*, or the geometrical underpinnings that inform one's composition as a whole and the interrelationships of its parts. This



2 Classical Parthenon, Athens. 447–438 B.C. Ground Plan. Drawing author, modified from M. Korres, in Korres 1994: Figure 2.

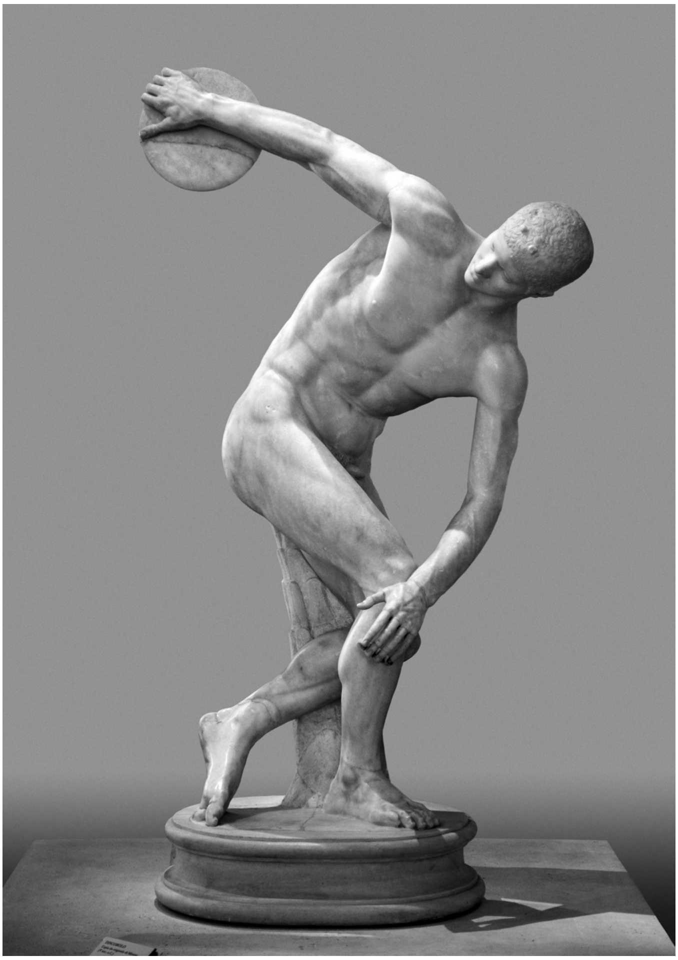
approach to design results in a sequential process that directly links the final built form with the first moments of drawing at small scale.[8]

The modern habituation with scale drawings may emerge from not only the ways that architects design, but also from institutionalized ways of thinking about buildings. After the initial publication of Sir Banister Fletcher's *A History of Architecture on the Comparative Method* in 1896,[9] historians of art and architecture came to largely understand the works of all periods through illustrations that compare buildings to one another, often at a strictly typological level. In turn, this kind of representation often serves to form part of the modern image of a given historical building. Relatively few introductory-level students are fortunate enough to experience the Parthenon for the first time when walking in the open air of the Athenian Akropolis rather than in a textbook or dark lecture hall where they view the temple by way of a small-scale set of black lines (Figure 2). This graphic illustration of a ground plan then becomes a part of a new generation's image of the Parthenon and comes to represent how architectural space is organized in ways that compare or contrast the supposed drawing board of Iktinos with that of Brunelleschi or Mies or Zaha Hadid.[10] In this way, drawing itself becomes an exceedingly familiar, culturally neutral act with a universal application in buildings across time that express vastly different forms and purposes.

In focusing on the gap that separates the instruments, methods, and applications of technical drawing in classical and modern architecture, the present study explores how craftsmanship conditioned vision in the classical world. As I argue, the shared habits of drawing in the art of building and the sciences became central to the entity that, in Roman times, would receive the designation of "architecture" passed down to western traditions of building. The shaping of order according the tools and techniques of craftsmanship directly impacted how Greeks saw the structures and mechanisms of nature, as well as the understanding of vision itself as articulated in philosophy and optical theory. Against this background, I present the Greek invention of linear perspective as reflective of existing procedures of drawing and influential for the heightened role of scale drawing in the organization of architectural space beginning in the Classical period (479–323 B.C.). In this exploration, I approach the Greek *theatron* – the "place for seeing" – as the earliest space expressly designed to shape vision, enhancing the rituals of spectacle associated with Greek practices of seeing that served the metaphor for "theory" itself as a new way of explaining the universe in abstract and internally coherent ways. The resulting "architectural vision" was to define how sacred and urban space was planned by way of ichnography, itself born of linear perspective in Greek painting. This book thereby considers the impact of the art of building on classical constructions and perceptions of the world.

With good reason, the centrality of scale graphic representations as an art historical focus in the manner of this book has been challenged in recent decades. Kevin Lynch's seminal sociological study of the ways in which westerners understand their cities as collectives of landmarks, nodes, paths, districts, and edges came to suggest an alternative model of analysis according to cognition at an experiential level.[11] For the classical material, studies of urban architecture have emphasized the integrated nature of Roman cities sensorily experienced at eye level by the ambulating subject who responded to partial, oblique, and gradually unfolding vistas.[12] Researchers have awoken an interest in the interaction of Roman viewers with the everyday experience of their cities through sequential, three-dimensional "armatures" comprised of piecemeal assemblages of structures over time rather than just urban plans or individual buildings studied as isolated ground plans, elevation drawings, and sections that do not correlate to how ancient buildings were actually seen. This methodology provides a salutary dose of imagination needed to restore a humanizing sense of life, motion, and even emotion to how buildings *worked* in antiquity.[13] In this way, a new historical narrative has relocated classical architecture in a kind of real space that allows one to grasp its former potential to be intuited temporally through the senses of the people who, driven by desire and necessity, lived and moved within it.

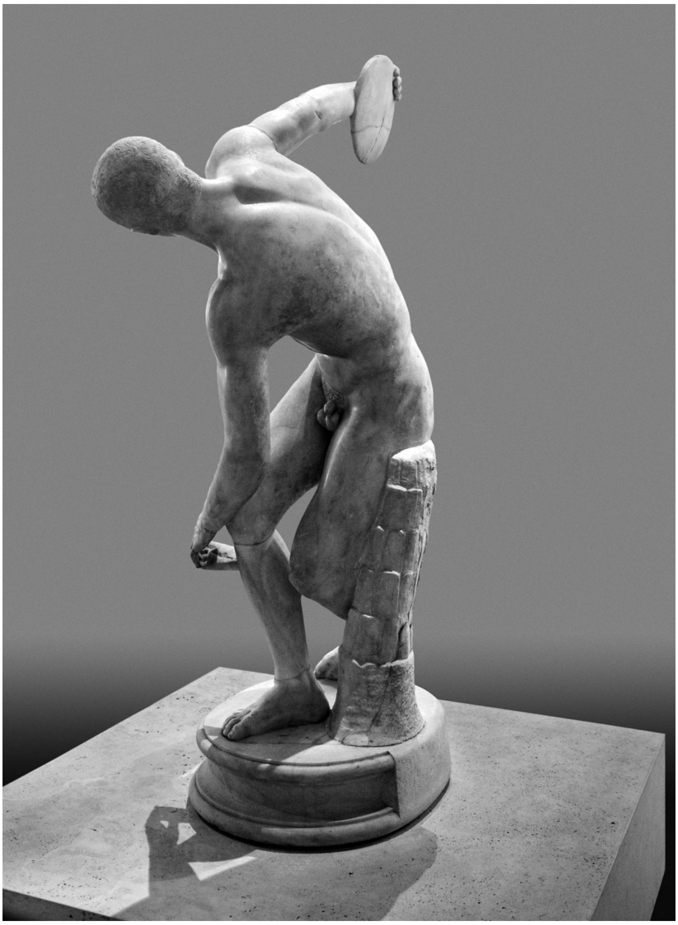
As opposed to buildings, complexes, and cities, sculptures need not involve a similar degree of changing perspective in motion on the part of the spectator. As a textbook example of a fixed frontal perspective, even a dynamic sculpture in the round like a Roman copy of Myron's Diskobolos of the mid-fifth century (Figures 3–4) disappoints rather than rewards the alternative perspectives of a wandering viewer's change of position, revealing a flatness and imbalance



3 Myron of Athens (fifth century B.C.). Diskobolos (Lancellotti Discobolus). Roman copy of Myron's bronze original of ca. 460–450 B.C. Frontal view. Marble. Museo Nazionale Romano (Palazzo Massimo alle Terme), Rome, Italy. Vanni/Art Resource, NY.

from the side that does little to break beyond even the static pose of an Archaic *kouros*.[14]

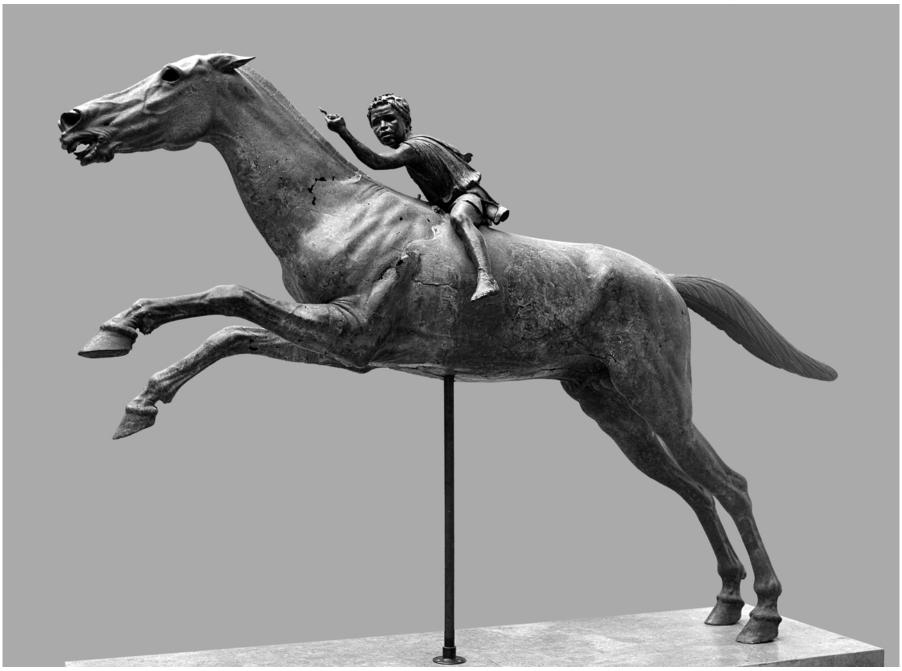
The unfolding, processual element found in classical architecture gains emphasis when one confronts sculpture of the Hellenistic period in particular. A defining feature of Hellenistic art is the extension of dynamism inherent in the work itself to the viewer's interaction with the work. As seen in the bronze horse and jockey pulled from an ancient shipwreck off Cape Artemision, this quality transcends the principal view normally presented in published photographs (Figure 5).[15] The boy turns his glance toward an invisible opponent with whom he seems to run neck-and-neck toward a "photo finish," his horse dedicating every muscle, fiber, and vein to the momentum and energy of the final push. In terms of the height of its original placement and its accessibility,



4 Myron of Athens (fifth century B.C.). Diskobolos (Lancellotti Discobolus). Roman copy of Myron's bronze original of ca. 460–450 B.C. Lateral view. Marble. Museo Nazionale Romano (Palazzo Massimo alle Terme), Rome, Italy. Vanni/Art Resource, NY.

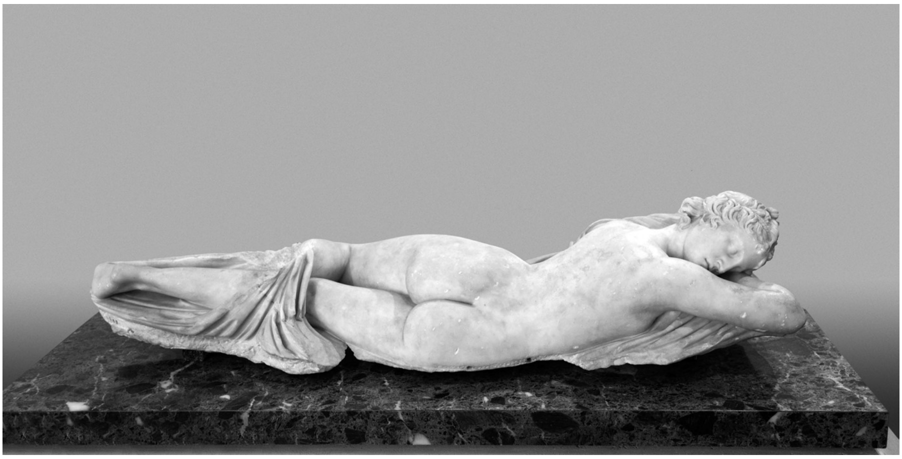
one cannot know how this work related to the perspective of ancient viewers, but it seems unlikely to have differed significantly from its current display in the National Archaeological Museum in Athens. Pulled in by curiosity, the engaged spectator may find himself drawn to a frontal view where the full impact of the horse's velocity may be felt at an adrenaline-releasing, and indeed personally endangering, intensity.[16] The tension between one's bodily reaction – the impulse to freeze or jump out of the way – and the mind's realization that this is merely sculpture internalizes the spectator's experience, breaking down the space that otherwise separates the viewer from the work in the manner of the Diskobolos, for example.

Perhaps one of the boldest Hellenistic expressions of vision in motion centers on Roman copies representing a figure that is anything but dynamic (Figure 6). Enticed by the erotic qualities of the sleeping figure, the unfolding experience



5 Horse and jockey. Hellenistic, ca. 150–125 B.C. Lateral view. Found off Cape Artemision, Greece. Bronze. Parts of horse's barrel restored, tail modern replacement. National Archaeological Museum, Athens, Greece. Vanni/Art Resource, NY.

of seeing results in perplexity and astonishment at a hermaphrodite's male genitalia, "a typically Hellenistic theatrical surprise."[17] As described here, the gradual, spatial, and temporal qualities of classical vision shows a kinship in the differing media of sculpture and architecture that appears to come into being in the Hellenistic period.



6 Sleeping hermaphrodite. Antonine copy (A.D. 138–192) of a Hellenistic original of the second century B.C. View of backside. Marble. Museo Nazionale Romano (Palazzo Massimo alle Terme), Rome, Italy. Vanni/Art Resource, NY.

Drawing and the Invention of Architecture

Beyond this very generalized classical context, however, there is a significant difference between the methods of creating that engendered the visual experience in sculpture as opposed to architecture. In this regard, the special case of architecture comes down to basic issues of definition. Strictly speaking, architecture as a distinct institution in the manner that Vitruvius recognizes it is difficult to isolate in ancient Greek culture through the Hellenistic period. In ancient Greek, the *techne* of building as a category with its own nounal designation (ἡ οἰκοδομική) seems to have suggested the art of the architect in the sense of the "builder" (οἰκόδομος).[18] Vitruvius' *architectura*, a Hellenized Latin term from the end of the Late Republic, carries something more of the explicit authority of the architect in the sense of the "master artificer" (ἀρχιτέκτων).[19] The term *architectura* thereby suggests a discipline of "master craftsmanship" that approximates the Greek adjective "architectonic" (ἀρχιτεκτονικός), describing not only the art of the master artificer of buildings (Plato *Statesman* 261c; Aristotle *Politics* 1282a3), but also the very concept of an authoritative master art that dictates to the persons and processes that serve it.

For Vitruvius, *architectura* consists of a set of Greek concepts given by mostly Greek terms that the Hellenistic builders who preceded him certainly would have identified with (*De architectura* 1.2.1–9).[20] Despite the close connections shared between builders and sculptors,[21] these concepts largely relate to drawing and presumably would have represented a salient point of difference between the arts of building and sculpture. In addition to the considerations of natural and financial resources, *architectura* consists of a process of graphic ordering grounded in a modular approach to quantity, and a process of design in the sense of correct graphic placement in accordance with the overall work. Finally, the principles of pleasing form and modular commensuration that these processes of drawing give rise to comprise *architectura*. As given in Vitruvius' definition of *architectura* in terms of what it consists of, it may be significant that architecture is identified entirely with issues of planning. More to the point, these processes and principles are embodied by three approaches to reduced-scale drawing: ichnography (the art ground plans), elevation or orthography, and linear perspective. This reliance on graphic representation is obviously distinct from the classical sculptural process using a sequence of models and casts.[22] In a workshop like that of Pheidias, a master sculptor might have conveyed his authoritative vision in the creation of a pedimental composition by way of plastic models. In Vitruvius' *architectura*, the three-dimensional construction of buildings conveying the qualities and principles envisioned by the architect takes place by way of a monumentalized imitation of the architect's authoritative vision as a graphically constructed *idea* (*De architectura* 1.2.2).

Regardless of the observable similarities in the unfolding spatial and temporal spectacle engendered in classical sculpture and architecture, then, the process by which this optical and kinesthetic experience was formalized is different. Yet it is not simply different in the sense of the natures of particular media. Rather, the differing process of design is central to what architecture consists of at the moment of its earliest institutionalizing definition in the writing of Vitruvius. The ownership of graphic construction as the domain of *cogitatio* (analysis) and *inventio* (invention) for the shaping of space according to good form and number (*De architectura* 1.2.2) carries important implications for the classical understanding of seeing itself. As the present study suggests, technical drawing and spectacle were connected in ways that had a profound impact on the awakening consciousness of an individual and separate discipline of architecture. Moreover, this study explores the relationship between drawing, seeing, and the birth of theoretical philosophy as an inward seeing associated with knowledge ("insight"), ways of envisioning nature, and even the nature of vision itself. The changing or multiple perspectives unified in the experience of Hellenistic sculptural works like those cited here (Figures 5, 6), I suggest, may very well represent a plastic exploitation of a notion first encountered in Greek drawing as an activity later so integrally identified with "architecture."

VISION, PHILOSOPHY, AND THE ART OF BUILDING

Vitruvius' account of architecture hints at an important connection between drawing and the experience of knowledge and seeing. According to him, the Greek term for the three kinds of reduced-scale drawing that define design (ichnography, elevation drawing, and linear perspective) is *ideai*.[23] Such drawings thereby share the same term (ἰδέα) used by Plato in his famous Theory of Forms to describe the transcendent Ideas underlying objects in the phenomenal realm, which are seen internally through the reasoning mind rather than externally through the eye.[24] In other words, there appears to be a correspondence between A) the *idea* as a graphic construction as opposed to the materialized construction that imitates it, and B) the *idea* as the immaterial object that the material object imitates. This correlation in building and philosophy between the graphic and transcendent (or "mental") image, along with an etymological connection between *idea* and seeing (ἰδεῖν, aorist infinitive of ὁράω), bridges across the centuries into Early Modern thought, as in Marsiglio Ficino's Neoplatonic commentary on Plato's *Symposium* in the fifteenth century A.D.:

> From the first moment the Architect conceives the reason and roughly the Idea of the building in his soul. Next he makes the house (as best he can) in such a way as it is available in his mind. Who will negate that the

> house is a body? And that this is very much like the incorporeal Idea of the craftsman, in whose imitation it has been made? Certainly it is more for a certain incorporeal order rather than for its material that it is to be judged. [25]

As noted by Heidegger, furthermore, for Kant's *Critique*, the association between pure reason and architectural drawing is explicit in the notion of a building's "inner structure" as a projection of the rational, graphic construction of the blueprint.[26] It may not be without basis, then, to consider the existence of an "architectural idealism" parallel to and interdependent with philosophical discourse in the western tradition going all the way back to Plato and the architects of his own era.

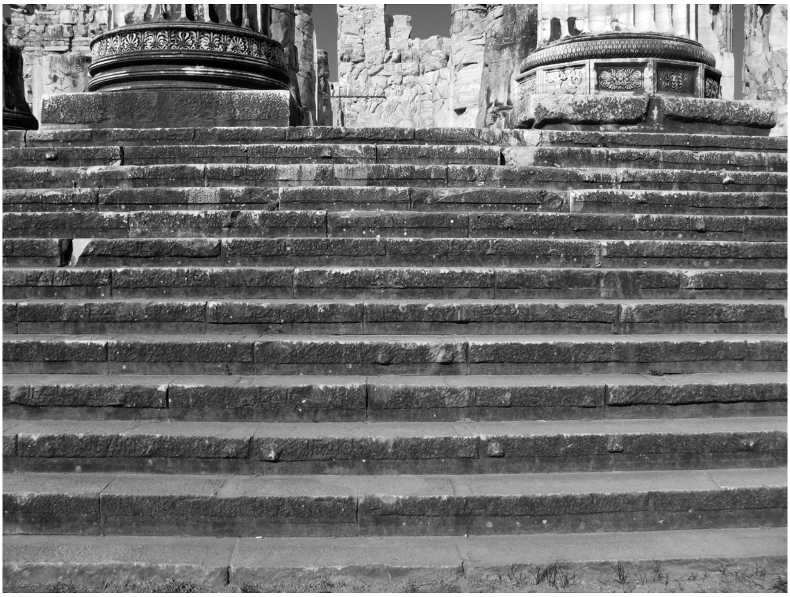
According to this understanding of the Platonic model, the privileging of drawings as fixed and eternal Ideas may seem to suggest for them a higher ontological status than that of their imitations as corporeal buildings subject to the ever incomplete, unfolding, and multiperspectival experience of them. To address the experience of buildings once again by way of sculpture, Plato himself offers some thoughts on the matter. In his discussion of *mimesis* in colossal sculpture in the *Sophist* (235d–236e), he mentions an older manner of replicating "the commensurations of the model" (τὰς τοῦ παραδείγματος συμμετρίας, 235d) in order to ensure "the true commensuration of beautiful forms" (τὴν τῶν καλῶν ἀληθινὴν συμμετρίαν, 235e). This older method and its beautiful result oppose the phantasms of his own time that alter proportions for a more correct appearance from the eye level of the viewer. J. J. Pollitt rightly connects this distinction of an older and newer method of sculpting with a reference in the first century by Diodoros Sikeliotes that distinguishes between the Egyptian manner of working according to a formula of proportions and the Greek interest in addressing optical appearance.[27]

A further suggestion, this time emerging from scholarship on Egyptian rather than Greek art, is that Plato's idealism as articulated in the Allegory of the Cave (*Republic* 514–517) itself parallels – and possibly reflects – the hieroglyphic nature of Egyptian art.[28] According to this view, signs in Egyptian writing, sculpture, and painting serve as archetypes unifying eternal essence and appearance. As such, Egyptian imagery denies the partial or multiperspectival view of reality in a way that anticipates Plato's denigration of visual appearances as shadows on a cave wall, locating knowledge in the immutable Idea grasped by the mind.

The implications of these connections in art and philosophy raise questions for the *ideai* of architecture. As rationally produced geometric forms lacking three-dimensional presence, did Greeks consider scale architectural drawings to correlate to Plato's archetypal Ideas with their intelligible rather than material existence? For Greek thinkers and architects, might these drawings have occupied a higher realm than their imperfect and derivative appearances in the corporeal world in the manner that Ficino suggests for Ideas during the Renaissance? As opposed to the sensory experience of buildings and cities emphasized by recent studies of ancient architecture, does Vitruvius' account of *ideai* and related passages reflect a body of Greek architectural theory that conversely emphasized geometry, proportion, and modular commensuration established graphically in a flat, planar realm far removed from embodied seeing in three-dimensional space?

In addressing such questions, an important caution in correlating philosophical idealism and architecture is that one had better properly grasp the former before exploring its supposed effects on the latter. If one presumes that Vitruvius' testimony for drawings as *ideai* reflects a tradition extending back to Plato, the flattening of architecture according to a supposed privileging of graphic construction should be careful not to flatten Plato in the process.[29] The flattening of Plato may, in fact, be an inadvertent though long-standing independent project whose tenets stand all too ready to aid in the reduction of architecture to an intellectually driven graphic exploration. Vitruvius' discussion of the *ideai* as products of a highly rational procedure involving number, calculation, and geometry does seem to recall Plato's emphasis on arithmetic and plane geometry, the latter serving as a means of directing the soul's vision toward the Idea of the Good and eternal being (*Republic* 526e, 527b). Yet the experience of this kind of vision is not just a rational apprehension of abstract relationships and archetypal forms rendered graphically with the compass and straightedge. A recent study by Andrea Wilson Nightingale assesses criticism of classical philosophy from Nietzsche through postmodern and contemporary thinkers, calling to question the repeated assertion that classical thought supposes a kind of objective knowledge directly and universally accessible to the mind that is free of cultural constructs and emotional factors.[30] Fully available to the subject without regard to perspective, the existence of Plato's *ideai* as objects of truth that unify essence and appearance certainly does find commonality with his privileging of plane geometry, the two-dimensional realm of architectural drawing, and the eternal and objective Egyptian hieroglyph presented frontally on the flat surface of the wall of a tomb. Yet in the Allegory of the Cave, it is only the shadows that are flat, seen through the eternally fixed, panoptic perspective of the fettered viewers – a shadow-puppet show as a perverse sort of spectacle.

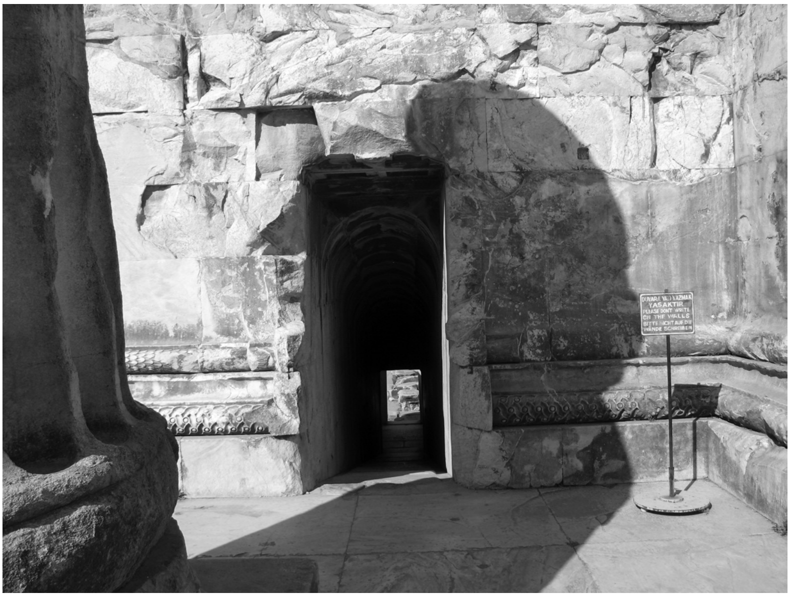
Breaking free from his chains, the philosopher's journey toward truth is anything but mere cerebral contemplation. Instead, it is highly emotional, erotic, and driven by desire.[31] Walking out of the cave and returning, the philosopher experiences pain and vexation, ascent and descent, the constriction and expansiveness of space, and even temporary blindness from the contrasts of darkness and light. More than the kind of detached thinker one finds in an Early Modern



7 Hellenistic Didymaion. Ascent toward stylobate. Photo author.

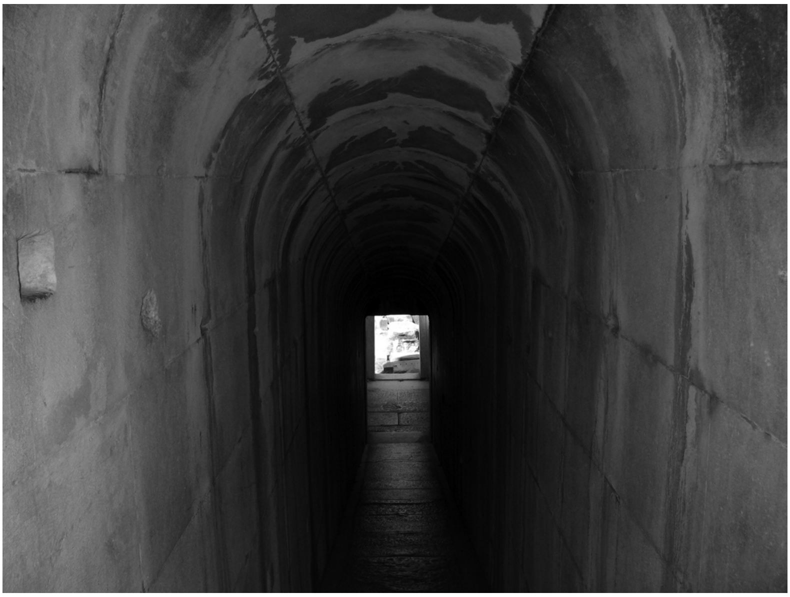
figure like Descartes, Plato's philosopher may call to mind the inhabitant or visitor of ancient Athens or indeed any city at any period, making his way among monuments, hovels, shops, taverns, and temples to find nourishment or intoxication, seek corporeal gratification and companionship, confront the divine, and to see. The difference between the philosopher's inward striving and the wandering of nonphilosophers is not a degree of experiential awareness during the progression of movement. Rather, it is the higher level of emotive intensity that both drives the philosopher forward and impacts him when he encounters his intended aim: the state of *thauma* as a kind of staggering astonishment or wonder and perplexity.[32] In the end, it is not a panoptic or frontal view that he confronts in the manner of a flat hieroglyph or elevation drawing, but only a partial view from an individual perspective that depends upon the preparedness and purity of the viewer's soul.[33]

In addition to the sensory experience in Roman urban architecture already so well analyzed by others, one may note a similar spirit in Hellenistic architectural design.[34] To cite but one example, the Hellenistic Didymaion is a masterwork when it comes to sensitivity in manifesting transitions in the path toward the sacred. The journey begins with an ascent up the frontal stairway to the tall stylobate (Figure 7), where one leaves behind the warmth and brightness of the sunlight for the shade and density of the "forest of columns" reaching upward 20 meters toward the roof. From this transitional space, one may continue forward down one of the two vaulted passageways (Figure 8). Now the progression becomes a descent as the transition from the space of the outer world to the



8 Hellenistic Didymaion. View of north passageway into the adyton from the stylobate. Photo author.

density of the porch becomes one of constriction, the body now enveloped by the coolness of marble and vision adjusted to near-total darkness save for the light at the end (Figure 9). Once the bottom is reached, the transition is a sudden and dramatic burst of warm and blinding light as one enters the holy of holies,



9 Hellenistic Didymaion. View within north passageway toward the adyton. Photo author.

the *adyton* or inner sanctuary open to the sky (Figure 10). Here, once the eyes adjust to the bright light of the sacred space, one confronts the divine, although in a way that is experienced only obscurely and obliquely through an oracular message.

Again, the multiplicity of perspectives encountered in this kind of wandering is characteristic of sculpture as well. In Plato's *Phaedrus*, Sokrates analogizes desire as a racing forward of horses that, in the confrontation with a boy's face as an object of desire, causes the charioteer to pull back the reins and come to a sudden stop (254b-c). In the all-around viewing of the horse and jockey (Figure 5), the thrilling sense of awe and fear in confrontation with the frontal perspective may remind one of the same passage (254b) where, in the viewing of beauty, Sokrates describes the fear and awe that causes the desirer to fall backward. Like the viewer of the Hellenistic sculpture, the charioteer becomes still. In this relationship, it is the boy whose being projects forward by way of a stream of beauty taken in by the eyes of the desirer. The position of having fallen backward is also the position of "upward seeing" described in the *Republic* (εἰς τὸ ἄνω ὁρᾶν, 529a), which, metaphorically, is the "correct" seeing of the beautiful by way of geometry (527b) or astronomy (529a). It is also the position for receiving that Sokrates describes metaphorically as copulation leading to a birthing (γεννήσας) of reason and truth that results in knowledge (490b). In the discussion of horses and the boy in the *Phaedrus*, interestingly, Sokrates characterizes this experience of earthly beauty as a statue whose luminous emission reflects the Idea of Beauty (251a, 252d), enabling the viewer's distant recollection of the preincarnate soul's experience of the Ideas displayed like cult statues in a sanctuary (254b).

To be clear, in no way do I suggest a Hellenistic sculptor or patron's intended correlation between the horse and jockey and Plato's texts. Rather, I bring together text and image to offer a culturally relevant reading of this sculpture while recognizing that its experience – both ancient and modern – can never be reduced to a set of textual references. At the same time, and more important for the present study, I hope to illustrate the qualities of the experience of seeing and its relationship to knowledge and spirituality that Plato describes. In this way, one may begin to address the roles of geometry and astronomy in a certain kind of seeing that is relevant to the question of *ideai* in the realm of art and building.

Pollitt's characterization of the viewer's unfolding experience of the sleeping hermaphrodite (Figure 6) as a "theatrical surprise" is a particularly suggestive observation for the classical understanding of the experience of seeing.[35] Another rich idea so typical of Pollitt's observations even at their most casual is that this work may "express a complex psychological and philosophical view of the psyche, the Platonic Idea that on a spiritual level the natures which we call female and male become one."[36] In light of the passages referenced earlier

10 Hellenistic Didymaion. View of adyton toward the *naiskos*. Photo author.

and later in this book, this interpretation is compelling and relevant to the question of theater as a kind of Greek visual experience that engenders truth and knowledge.[37]

I would suggest that Plato's metaphor of receptive lovemaking – the attainment of knowledge through the soul's metaphysical copulation with the "really real" and subsequent birthing of intelligence and truth – is especially meaningful because of its dependence on a related, more primary metaphor. By this I mean a way in which, in esoteric thought, primary metaphors may themselves engender additional metaphors that enhance the essential image. In this move, the message becomes extraordinarily subtle, requiring a watchful rethinking of the nature of things like gender and sexuality outside of their usual culturally based associations. By analogy, it may be useful to recall the *Tao Te Ching*, the ancient Chinese sacred text that invites the reader to open himself to the *Tao*, a linguistically indefinable force or presence expressed though the metaphor of flowing. Enriching this metaphor is the *Yin*, the female principle associated with earth, darkness, and coldness, and the *Yang*, the male principle associated with the heavens, heat, and light.[38] It would be useless to think of this distinction in terms of cultural constructs of gender roles. Instead, there is something poetic and primordial at work in which both the sage and the earth embrace *Yin*, playing the role of woman, "the valley spirit" that lies still and low, opening to receive the flow of the *Tao* in order to bring forth the universe.[39]

As in the *Yang*, for Plato as well there is the repeated metaphor of a creative outflow of light. Yet the Idea of the Good does not simply illuminate the intelligible realm. It also gives birth to the sun in the phenomenal realm. Similarly, the philosopher must receive a flow from the Ideas in order to give birth to truth through his own actions in daily life. As in the unfolding vision of the sleeping hermaphrodite, the desire that drives one forward must ultimately halt and give way to reception from the Idea that itself plays both roles.

For both Plato and the Chinese text, however, the gendered metaphor of emission, reception, and birth relate to a primary metaphor rather than adding a new concept needing to be contemplated separately. In both, the metaphor that receptive lovemaking depends on and enhances is that of flow, which for Plato at least is a characteristic of vision. In other words, Plato does not cast aside the metaphor of seeing in favor of copulation once the Ideas are encountered. The soul's active, *eros*-driven journey of the unfolding, perspectival process of vision leading toward the Idea of the Good must embrace a passive and transfixed receiving of its flow.[40] Nonetheless, the colorfully sexual character of this encounter is still what Plato calls "the soul's vision" (τὴν τῆς ψυχῆς ὄψιν, *Republic* 519b). Like the vision of beauty in the phenomenal realm, it is a penetration into the eyes, which takes place in "the eye of the soul" (τὸ τῆς ψυχῆς ὄμμα, 533d) as well.

The metaphor of sex therefore heightens the reader's awareness of the experience of seeing, amplifying the dual function of the eye as an organ that, like the dual parts of the hermaphrodite, both receives influx and flows outward. For Plato, light from the inner eye flows outward and coalesces with the light of the outer world to form a single body (*Timaeus* 45b-c). In this way, vision involves an intimate and even tactile relationship between subject and object.

This experience in the phenomenal realm is akin to the encounter with the intelligible *ideai*, but for Plato the metaphor is enhanced by a particular institutionalized activity. The way we speak of "theory" had its beginnings in Plato's metaphor of *theoria*, the journey of a *theoros* or envoy to see spectacles associated with religious festivals at another city-state and then return home to give an account of what he had witnessed,[41] just as in the Allegory of the Cave where the escaped prisoner who sees the light of the sun returns to describe his experiences to his fellow prisoners still bound in the darkness.[42] In Plato's usage, *theoria* describes not the traditional sort of journey in the outside world, but rather the philosopher's *inward* journey that culminates in seeing the *ideai*, his generation of knowledge and truth, and return home to describe his experience. Significantly, however, this ideal, intimate experience of the *ideai* lies beyond the reach of incarnate philosophers in the world, including even Sokrates. At best, the actual philosopher in the world (as opposed to the ideal philosopher) can attain only a partial view of the *ideai*.

In his dialectic, therefore, Plato makes extensive use of analogies and metaphors borrowed from the phenomenal world, writing in ways that the reader can relate to by way of common experience. One tantalizing reference in the *Republic* (529c-e) suggests that the philosopher must treat the revolving astral bodies as *paradeigmata* ("models"). As *paradeigmata*, they are comparable to what one would see "if one came across diagrams (διαγράμμασιν) drawn and precisely worked through by Daidalos or a different craftsman or painter."[43] The "most beautiful" geometry of these drawings may serve as a vehicle for approaching transcendent reality through vision, even though such models in the phenomenal realm cannot embody truth in itself. In the *Timaeus*, subsequently, Plato describes the cosmos as the creation of a divine craftsman according to a *paradeigma* (28c–29a), again using the terminology from the crafts of building and painting.

In this study, I argue that Plato may have taken from craftsmanship a second metaphor, the *idea*, which, other than in Vitruvius' late text, remains largely unattested to due to the disappearance of Greek architectural writing. Plato relates the term to craftsmanship (*Republic* 596b), but in the craft of building in particular it gains special meaning as a drawing able to clearly convey the architect's vision to be carried out on site by several craftsmen. What made Plato's metaphor (rather than invention) of the *ideai* meaningful was that, for reasons that I explore, these architectural *ideai* themselves related to cosmic order through a kinship with astronomical diagrams. In this kinship, these two applications of drawing – architectural and astronomical – originate together as expressions of order engendered through the existing tools and practices of technical drawing first explored in building design and construction at an early date. Whether as ichnographies, orthographies, perspectives, or even graphic images of the revolving mechanisms of the cosmos, for Plato these drawings would have presented to the eyes beautiful though distant imitations of the underlying sense of order that, metaphorically speaking, the divine craftsman built into the universe. In evoking this vision in Plato's discussion of the ideal philosopher's encounter with the Ideas, seeing itself is a metaphor for a kind of direct, full, and penetrating contact with the ultimate transcendent realities. Through the viewing and imitation of this geometric order of the cosmos in one's incarnate body in the physical world, one redirects his soul's vision upward in the manner previously described in preparation to receive the Ideas. Finally, the metaphor of *theoria* expresses the entire sequence from the journey toward the Ideas to the account of this experience.

The chapters that follow explore the genesis of "theory" in the connection between knowledge and seeing that, for the rituals of theater, first came together in architecture. More precisely, this connection belonged to what would receive the designation of "architecture" in the Late Republic at the close of the Hellenistic period, but what began as a shift to a kind of building centered on representational space through reduced-scale drawing. Technical drawing as such was a practice shared by the art of building and other craftsmanship, astronomy, and geometry as well as the related field of optics, and together these fields produced an inseparable nexus of instruments, methods, and representations that defined order in visual terms. Through this development, the craft of building expanded its focus from sculptural expressions of mass to constructions of space as three-dimensional projections of ordering principles or ideas explored with the compass and straightedge: axes, radial lines, circumferences, archetypal polygons (Pythagorean triangles, squares, and other equilateral forms), and so forth.

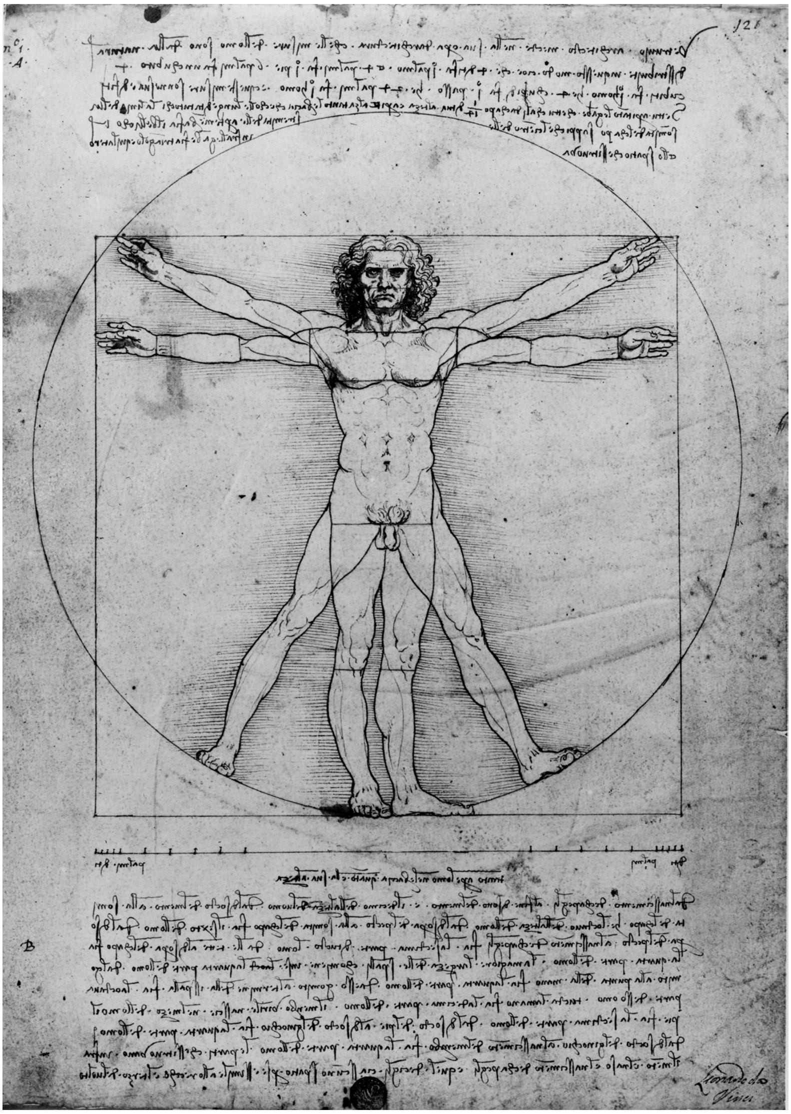
In the age of *architectura* in the Roman world, these ordering ideas would eventually become *formal* principles that defined spatial experience in three dimensions in ways that were previously unimaginable. Rather than simply underpinning form, the ideas became forms in a concrete sense as Roman architects gained command of *opus caementicium* as a medium whose fluidity could bring forth the curvilinear and polygonal character of drawing with the compass and straightedge. Without question, this development represents a uniquely Roman creative feat that was anything but a mere plastic translation of earlier Greek graphic practices, and it is far from my intention to claim the primacy of Greek culture in what was arguably the invention of the very possibility of a European tradition of architecture. Nor is it within the scope of this brief study to explore any aspects of this "Roman architectural revolution," a subject so admirably addressed long ago.[44] Rather, from the perspective of this study, a conflation of the Roman architectural achievement with the *ideai* of the Greeks may be likened to Vitruvius' criticism of the Greek architect Pytheos who confused the work itself with the reasoning, *ratiocinatione*, that underlies it. Following Plato's adaptation of the term *theoria*, this reasoning is the seeing and accounting of ideas shared by many disciplines that stand behind actual production according to the skills of a single discipline. As Vitruvius explains it:

> . . . astronomers and musicians discuss certain things in common: the harmony of the stars, the intervals of squares and triangles, that is, the [musical] intervals of fourths and fifths, and with geometers they speak about vision, which in Greek is called *logos optikos*, the science of optics, and in the other disciplines many – or all – things are common property, so far as discussion is concerned. But as for embarking on the creation of works that are brought to elegant conclusion . . . this is properly left to those who have been trained to practice a single skill.[45] (*De architectura* 1.1.16)

The circumferential, polygonal, and polyaxial geometry that drove the design of Greek and Hellenistic buildings and complexes was theoretical, existing as an underpinning of form at reduced scale in the realm of the drawing board. With the important exception of the Greek theater, this kind of drawing – which also characterized technical drawing in astronomy and optics – was "brought to elegant conclusion" only with the aid of concrete in the Roman Imperial period, a fluid medium that builders could cast in the enveloping, monumental forms reflecting designs that manipulations of the compass and straightedge engendered (as in Figure 1). Furthermore, the genius of Roman architecture includes not only a new kind of spatial experience, but also a new kind of institutional space in the invention of architecture itself as a separate sphere worthy to occupy the attention of the *Imperator* (Vitruvius' ten books are offered to Augustus) alongside astronomy, music, geometry and the related field of optics, and other such disciplines.

Regardless of whether Vitruvius intended to elevate his own position and that of the trade of architects through his detailed theoretical account of architecture,[46] there is an additional possibility that I explore below. This is the possibility of what it means for theory itself to have come into being as a set of ideas able to be shared among disciplines: That as *ideai*, these ideas or principles were caught up with an explicitly visual nature, a claim whose strangeness may be assuaged by the realization that the *ideai* were related to what it meant to see (ἰδεῖν), and that this seeing was discovered largely through drawing for the purpose of building. In a manner to be accounted for in the present study, *thea* (seeing or spectacle) gains a "theoretical" quality through an envisioning of *theoria* (an envoy's seeing of truth) according to geometric and optical models that first came into being in the graphic planning of the architectural type of the *theatron* (the place for seeing) as early as the fifth century. Among the many implications of this circumstance, one may include one that, in a way that would have doubtlessly been forgotten long before the first century, the art of building that Vitruvius' theory elevates itself played a role in the very genesis of theory. Perhaps more important, the *ideai* of the Greeks described by Vitruvius as underlying nature and buildings (Figure 11) would become enduring figures to be reinterpreted throughout the history of western visual culture. More than this, they would come to define the idea of architecture and the reshaping of the built environment that came to full prominence in the Roman Imperial period. In ways that I explore later in this book, this reshaping may have begun in the Classical period of the fifth century and laid the groundwork for the total reshaping of the architectural vision of cosmic space centuries later (Figure 1).

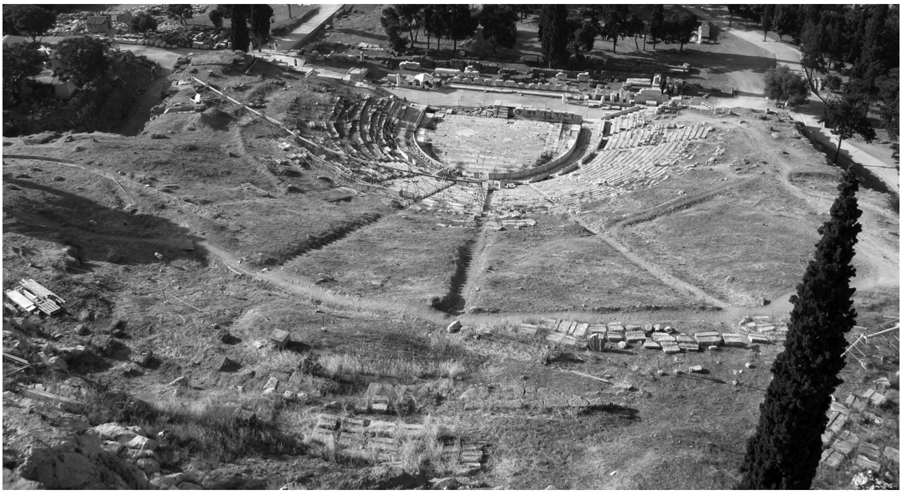
To explore the subject of Greek technical drawing, then, is to enter into the transcendent guiding principles that ordered how Greek architects conceived of and constructed space and the experience of vision itself, including linear perspective. Penetration to such an unlikely realm requires detailed analysis and synthesis of different kinds of scarcely surviving evidence – metrological, mathematical, and textual – from different contexts associated with different kinds of buildings that preserve the potential to shed light onto a disembodied process separated from us by two millennia and connected to us by little more



11 Leonardo da Vinci (1452–1519). The "Vitruvian Man" defined by sample modules, proportions, and geometry, as described by Vitruvius (*De arch.* 3.1.2–3). Accademia, Venice, Italy. Alinari/Art Resource, NY.

than our shared humanity. More than just a description of evolving approaches to architectural design, our restoration of even a semblance of this process allows us to confront a fundamental shift in the conception of form that would come to change the very shape of classical experience in sacred and urban environments.

In this spirit, I suggest what may appear to some an unlikely attitude with which one may approach the subject of geometry in classical architecture. Geometry and classical architecture both may commonly evoke for us a



12 Theater of Dionysos, Athens. Begun ca. 370 B.C. View from Akropolis. Photo author.

characterization like "cerebral." It is a textbook commonplace to acknowledge how, in Early Modern architecture, Mannerism or the Baroque introduced unexpected combinations of elements or fusions of media (architecture, figural sculpture, stucco, painting, etc.) and dynamic undulation in order to enliven the repetitive forms and formulas of the classical tradition. As for the ancient material, with the exception of later antiquarian references and descriptions, we lack testimony of how Greeks of the Classical period commonly reacted to the crystalline perfection and subtle refinements of masonry in a building like the Parthenon.[47] Whether we today respond individually to such monuments with awe or merely polite respect,[48] it is not difficult to imagine a vast majority of Classical Athenians and visitors reacting to these new forms in a way that tended toward the former. Nor would the first association with geometry for such viewers have been simply arcane theorems and diagrams, but more likely the details and overall forms of the building themselves, from the fluting of the Erechtheion's columns to unprecedented, sweeping, monumental curvature of the Theater of Dionysos (Figure 12).

Plato's emphasis on the *beauty* of geometry analyzed in Chapter 1 may suggest that such forms in the built world were not just "rational" expressions, but also deeply moving. According to ways that I address throughout this book, geometric form originating in the art of building may have allowed Plato to envision a sense of cosmic order that, as an object of the mind's contemplation, moves one toward a confrontation with the divine. Geometry in the sacred space of the temple, theater, or (in the writing of Plato) the architectural product of the cosmos itself was arguably anything but cerebral, and there is little justification for approaching it as a subject somehow removed from our broader humanistic interests in philosophy and art.

AUDIENCE, STRUCTURE, AND APPROACH

Yet there are challenges of analysis such as an interdisciplinary exploration, requiring the reader to confront different kinds of evidence. In establishing connections that are consequential to the histories of art and architecture, philosophy, and science, this book's audience becomes diverse. Although primarily intended for art and architectural historians and classical archaeologists, it will also be of interest to a broad range of classicists and students interested in the history of philosophy and science, as well as architects interested in the classical world. In today's interdisciplinary environment, there is notable overlap between these fields, and commonly students who engage primarily with visual objects are as comfortable with texts as students of classical literature are with works of architecture, sculpture, and painting. Nonetheless, the challenge of embracing such different kinds of evidence is real, and in providing detailed analysis of both buildings and texts, the chapters following indeed tackle two separate inquiries that are traditionally the domain of separate disciplines. In the case of readers who may be equally habituated with both approaches, furthermore, there is always a question of *inclination*, sometimes fluctuating back and forth periodically even for an individual reader.

The implications of this study for art and thought therefore necessitate accessibility for readers with different habits and inclinations. This is especially the case in Chapter 1, in which in-depth analyses of buildings and texts infer connections between the art of building, philosophical inquiry, optical theory, and cosmic representation that run through a nexus of Greek cultural productivity and create the very possibility for architecture as defined by Vitruvius. Since these connections establish a foundation for the remainder of the book, limited technical terms and copious illustrations accompany discussions of buildings, and extensive use of parenthetical translations enable critical engagement with the analysis presented.

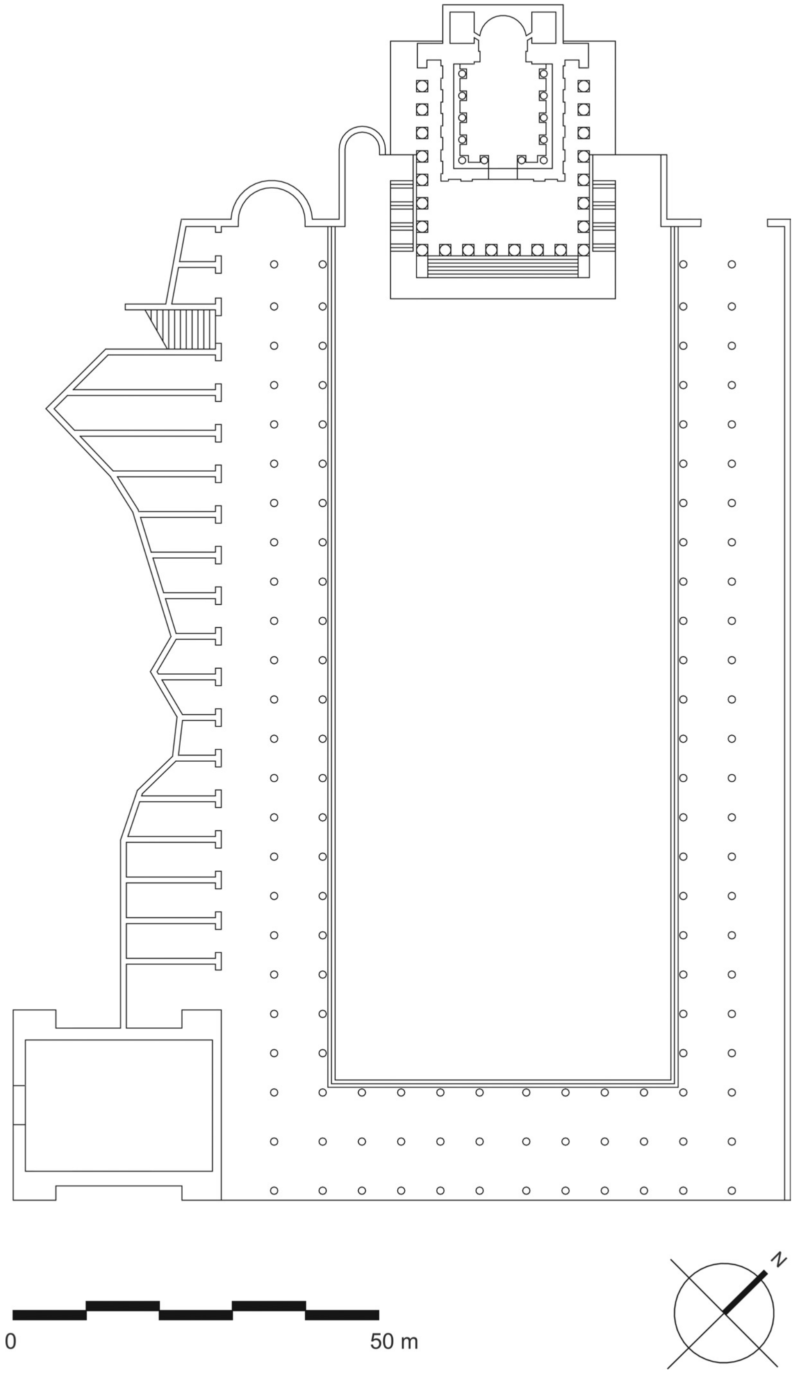
Chapter 1's heavy emphasis on both buildings and texts requires explanation. As I hope will be clear, an analysis of material evidence in the first part of that chapter elicits a turn to literary sources. This transition is far from seamless. In doing so, however, the evaluation of texts opens new approaches to the analysis of buildings, radically changing the questions asked about the art of building and the further kinds of evidence required for examination of classical architectural theory and practice. At the end of the book, an Excursus analyzing the evidence of Plato and related sources for our understanding of classical architectural drawing supplements the arguments of Chapter 1.

In Chapter 2, I identify the historical connections and practices of technical drawing shared by the Greek craft of building, astronomy, and optical theory. In addition, I address how all three of these fields provided meaningful antecedents for the role of craftsmanship, astral motion, and vision in Plato's metaphorical discussions of truth. More important, this chapter argues that Plato's use of the term *idea* in a metaphysical sense may indeed have followed upon an existing nonphilosophical application of the term in association with reduced-scale architectural drawing that long preceded Vitruvius. Based on a reading of Aristophanes, I assess textual evidence for the invention of linear perspective as a background for approaching the reshaping of the Theater of Dionysos in Athens. I also interpret the implications of what one may learn from Greek drawing in the service of painting and building for our understanding of metaphors that Plato employs in his *Republic*.

Chapter 3 explores the invention of reduced-scale architectural drawing as the progeny of traditional practices of full-scale drawing for individual elements, the techniques and principles of which influenced drawing and the related shaping of order in craftsmanship and technical diagrams. Drawing on the discoveries and theories of Lothar Haselberger to whom this line of inquiry is heavily indebted, Chapter 3 identifies two dominant approaches to protraction through technical drawing – one for the refinements of entasis and curvature, and one for the fluting of columns – as well as consider the relationship between them. As part of this projection of design practice from single features to expansive architectural space, I argue for a simple apparatus of design in which the primary application of the compass and straightedge developed a third indispensable tool, the "curved ruler" or protractor that extended graphic algorithms into the field of vision as principle of protraction. The resulting invention of linear perspective for the painting of theater backdrops is then assessed as a device according to which the same projection of visual rays into space now shaped architecture through ichnography.

Chapter 4 discusses how repeated habits of drawing in the craft of building created new ways of seeing nature that, in turn, changed how buildings and environments were shaped. This chapter's focus is Vitruvius' writing as a reflection of Greek theory on design applied in the ichnography of Hellenistic sanctuaries. Central to this analysis is the "Vitruvian Man" (Figure 11) as a model for ichnography in the design process of temples. Chapter 4 also provides further support for my conjecture that reduced-scale architectural design emerged from repeated practices of drawing in the geometric construction of architectural elements and refinements. This final chapter concludes by addressing the further application of ichnography to architectural complexes, shaping whole environments in addition to isolated buildings.

The exploitation of this latter approach to design was to be of great consequence to the future development of the art of building in its Roman context. Caesar's Forum (Figure 13) initiated the Imperial fora that perhaps represent the culmination of continuing tendencies toward axis and enclosure, completing Rome's transformation into a sequence of portico-framed precincts stretching from the Circus Flaminius and Campus Martius to the city center. In addition



13 Forum of Caesar, Rome. Begun after 48 B.C. Restored ground plan. Drawing author, modified from C. Amici, in Amici 1991: Plate 160.

to the curvilinear and polygonal aesthetic made possible by Roman concrete, these porticoed enclosures, too, bring forth a potential for constructing space first explored on the drawing boards of architects in the Greek-speaking world. Again, the creativity in applying such approaches to design in a Roman urban context to suit specifically Roman needs was a Roman phenomenon rather than the inevitable *telos* of an originally Greek practice. On the contrary, the institution of architecture itself, capable of its own set of imagery and the *corpus* of Vitruvius that theorizes it, is a Roman invention.

Yet to pursue the threads underlying Roman architecture by way of graphic considerations to their Greek genesis involves immense challenges of interpretation beyond even the paucity of surviving Greek architectural drawings and writings. Rather than remaining fastened to one another and to the significance they engender, these threads spread in torn fragments blowing over and buried within a varied landscape. Nor does this ruinous state result from merely the destruction or corruption of evidence over time; in the realm of art and thought, even well-preserved evidence rarely, if ever, leaves clear traces of intended influences that makers and writers actively or consciously unite for their own expressions. Furthermore, our interpretations are open to the dangers of anachronism in the study of architecture from an age when builders lacked our post-Vitruvian (let alone Postmodern) conception of the canons of its methods of production.

Nonetheless, in the face of each of these pitfalls and several others, the biggest challenge of interpretation may be the challenge *to* interpret. I contend that recent studies of Greek buildings and evidence for their architects' processes of design has been simply too solid, and the material itself too important, to not attempt to reconnect the torn threads across their interstices as a means of penetrating to what Romans like Vitruvius may have seen as the possibility of architecture: A discipline that depended on drawings as its guiding ideas to create a sense of order in the built world akin to the very sense of order built into the cosmos.

ONE

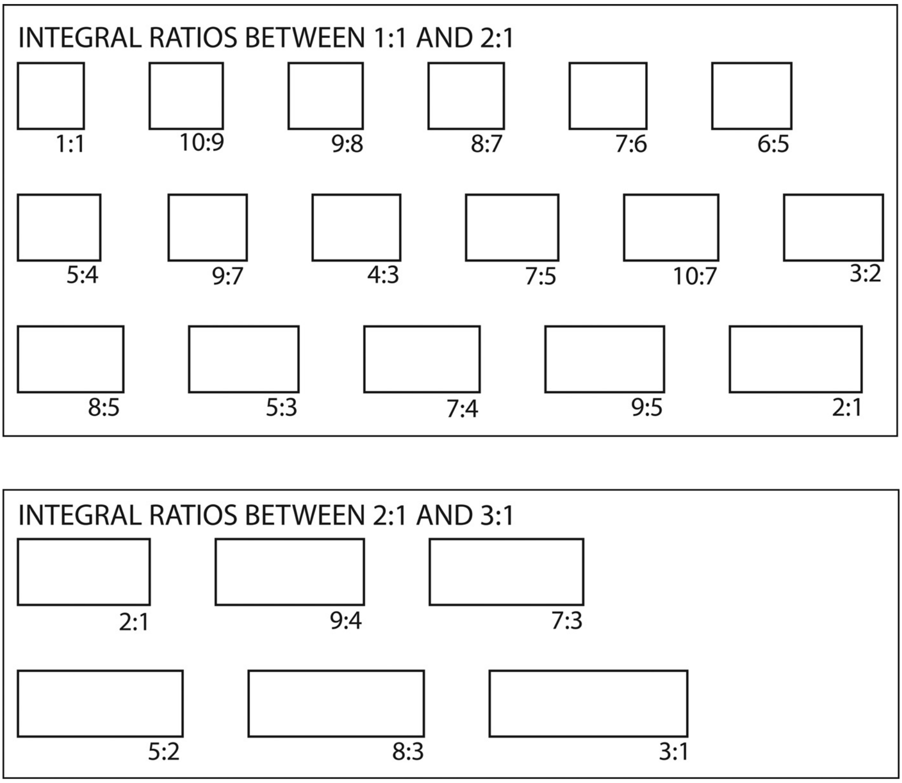
THE IDEAS OF ARCHITECTURE

This chapter addresses how temple buildings were created during the Archaic and Classical periods. Moving through the challenges of understanding the processes of creating buildings before the Late Classical period in the fourth century, the following observations and arguments orientate one toward specific concerns of design in both standard and innovative temples. Resulting from this exploration, the present chapter highlights the discordance between natural vision and the abstract notion of ichnography in particular.

REDUCED-SCALE DRAWING

No matter how naturalized the relationship between scale drawing and architecture has become for us, we cannot expect the same case to have existed in Hellenic architecture. For material dating to before the Hellenistic period, there has not been scholarly consensus as to whether Greek buildings were products of scale drawing.[1] Vitruvius' writings reflect an understanding of architectural drawing as held in the Hellenistic world, but beyond nonarchitectural writers like Plato and others, we lack testimony on the methods of planning common to architects of the Classical period and earlier.[2]

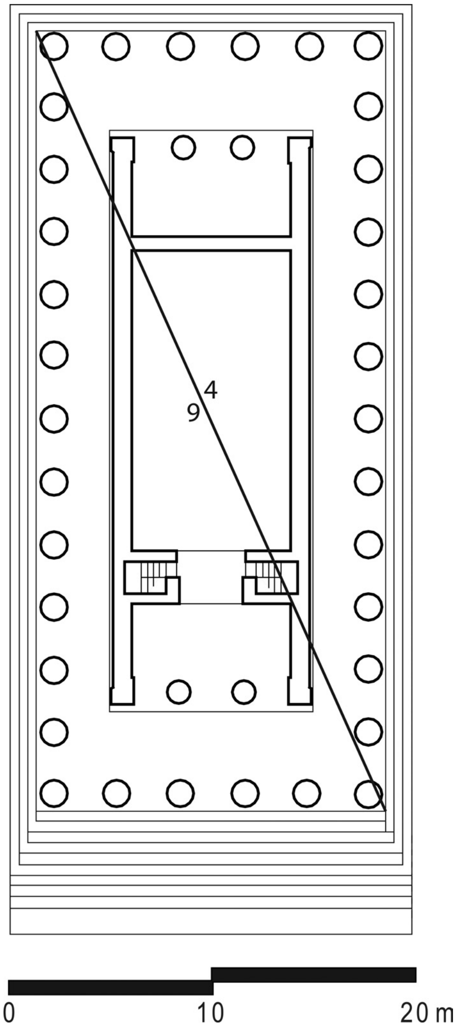
Metrological and proportional studies bear out the difficulties in recognizing Classical temples as products of scale drawing. Relatively recent criticism of earlier scholarly assumptions about the design process in (as far as architectural writing goes) the poorly documented fifth century helps us recognize that temples of the Classical period were expressions of an extremely rational process of planning.[3] Yet the method of this rational approach need not have been graphic exploration at the drawing board. Instead, the process seems to have been driven largely by integral numerical relationships translated arithmetically



14 Whole number ratios used in Greek temple buildings of the Classical period. Drawing author, based on analysis of D. Mertens and adapted from Mertens 1984b: Figure 1.

into metric specifications. In temple after temple, architects repeated common ratios that engendered the visual forms for individual elements, relationships between elements, and overall features like the rectangle of the façade defined by selected features.[4] In this way, the forms corresponding to these ratios were readily envisioned without the need for irrational proportional relationships newly discovered by individual architects through drawings or models (Figure 14).[5] Such whole-number ratios are found in several examples from the Archaic and Classical periods in both elevation and plan in Magna Graecia (Figures 15 and 16) and mainland Greece, suggesting a widespread method of design that would have rendered reduced-scale drawing superfluous.[6]

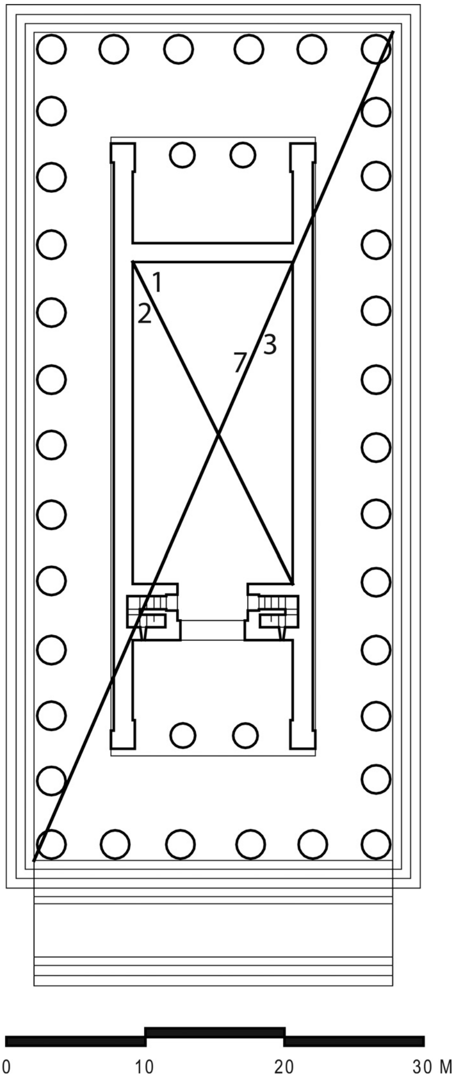
A further caution against seeing reduced-scale drawing at work in temples dating to before the fourth century arises from the realization that the integral proportions underlying a building like the temple at Segesta (Figure 17) need not represent an ancient method of engendering a desired visual effect. Mark Wilson Jones rightly distinguishes between visual and schematic proportions, with the latter adopted and repeated for their convenience in design process rather than their experiential qualities.[7] This distinction finds further support



15 Temple of Juno Lacinia, Agrigento. Ca. 455 B.C. Plan showing integral ratio of 4:9 between width and length of stylobate. Drawing author, modified from D. Mertens, in Mertens 1984b: Figure 3.

in cases where the locations of Classical buildings involve special considerations of design for the experience of viewing.

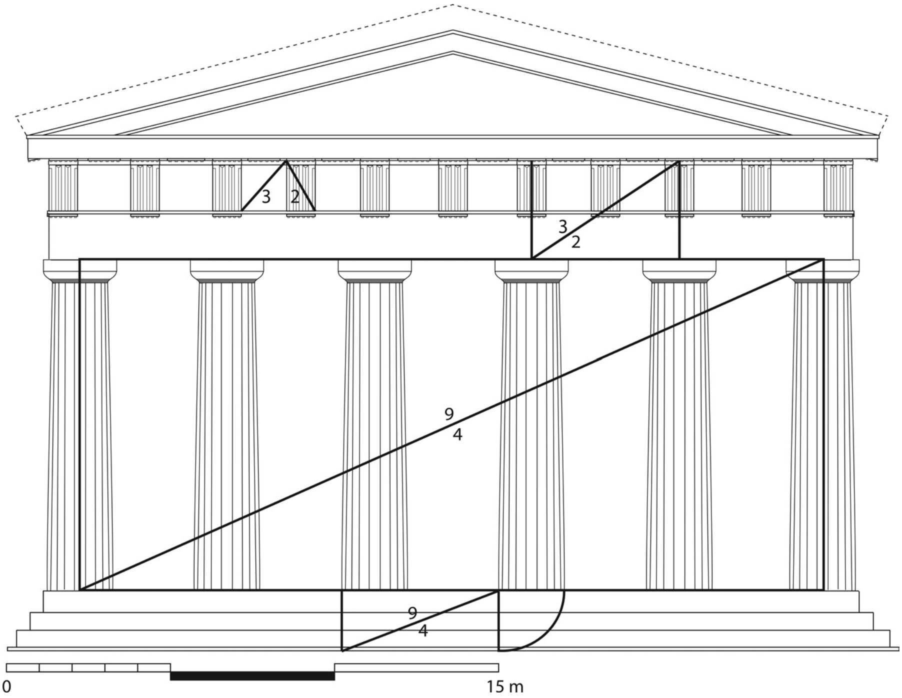
As in the temple at Segesta and many other coeval examples, integral ratio guides the design of the elevation of the Hephaisteion in Athens. Here, a 1:3 ratio establishes the height of the order in relation to the axial distances between columns, and there is a 1:2 ratio for the principal rectangle of the façade (Figure 18).[8] Due to the constricted space of the temple's location at the eastern edge of the Kolonos Agoraios, however, only oblique views of the façade are possible. From this confined perspective, one finds that there are only four sculpted metopes at the eastern end on the flanks (Figure 19), suggesting that the principal view of the temple is in front, and therefore from the level of the busy Agora below.[9] Yet this perspective creates a vertical compression, thereby altering the visual correspondence to the whole-number proportions.



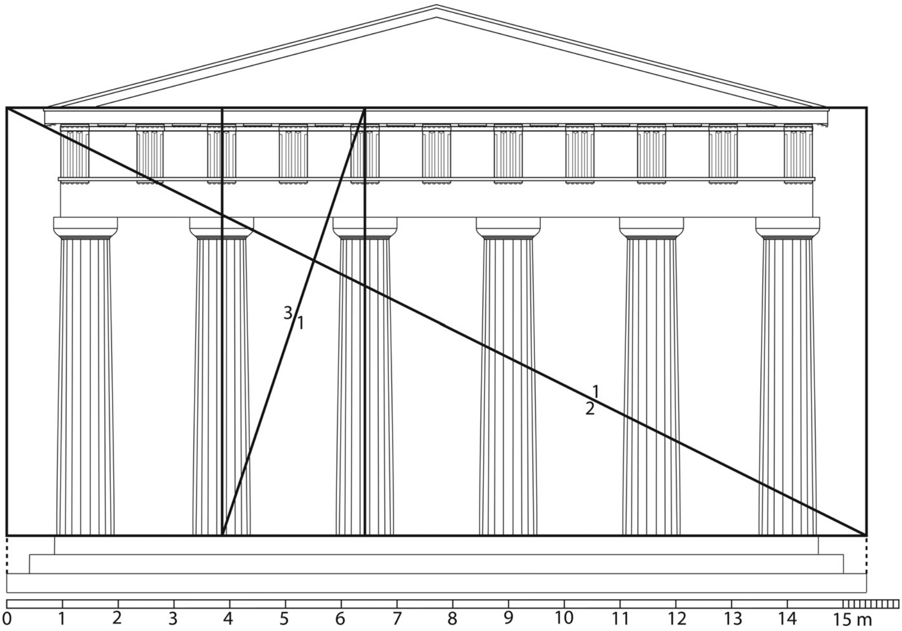
16 Temple of Concordia, Agrigento. Ca. 435 B.C. plan showing integral ratios of 3:7 and 1:2 between width and length of the stylobate and interior cella, respectively. Drawing author, modified from D. Mertens, in Mertens 1984b: Figure 3.

In the case of the Parthenon, the 4:9 ratio of the principal rectangle of the façade appeals to its eastern front, but not from the lower vantage point of "the first good view of the Parthenon" from below the great steps at the level of the Khalkotheke terrace to the west.[10] The clear views from the even lower vantage points of the Propylaia or the Pnyx hill enjoyed today do not correspond to ancient experience.[11] If any adjustment was made for visual experience in the Parthenon or Hephaisteion, it was in the increased height of the latter's columns relative to their slender diameters, as well as a relatively high entablature.[12]

An additional indication of the schematic rather than visual nature of such integral proportions is the presence of visual "refinements" in features that have nothing to do with ratios like 1:2, 1:3, and 4:9.[13] Refinements like convex curvature in horizontal elements, as well as columns (a subtle swelling of the


3
2
3
2
9
4
9
4
0
15 m

17 Temple at Segesta. Fifth century B.C. (before 409). Elevation showing integral proportions. Drawing author, modified from M. Schützenberger, in Mertens 2006: Figure 705.


3
1
1
2
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15 m

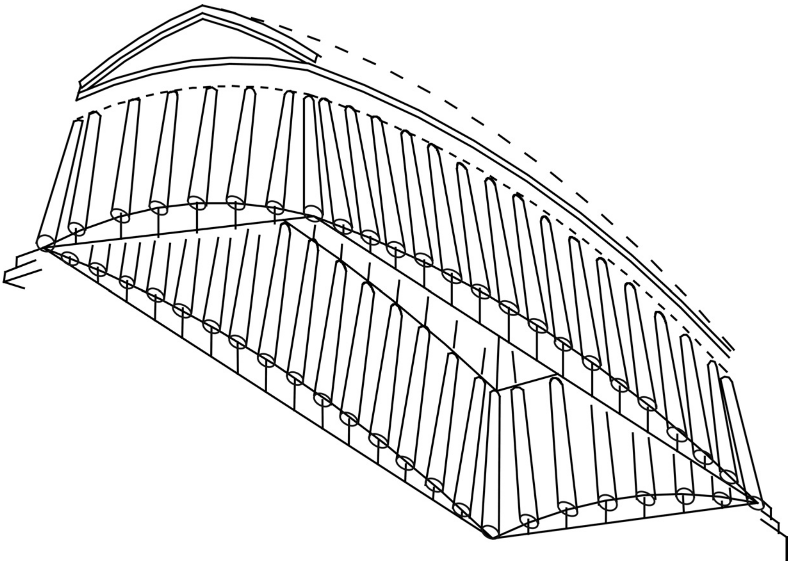
18 Hephaisteion, Athens. Ca. 450–445 B.C. Elevation showing integral proportions. Drawing author.

19 Hephaisteion, Athens. View at southeast corner (Agora side). Photo author.

shafts known as entasis) and the inward leaning of columns (Figure 20), may have been intended to correct faulty optical impressions.[14]

Beyond these deviations, "refinements of refinements" in the Parthenon created a subtle play of adjusted elevation and curvature as imagined for the viewer's perspective at eye level and in real dimensions, reflecting an incredibly acute awareness in design (Figure 21).[15] The terrace on which both the Archaic and Periklean Parthenon originally stood is no longer a visible presence,[16] but when viewed from the originally important vantage point of northwest while standing at the level of the Sacred Way, the temple's oblique placement would cause an optically inferred convergence of the lower krepis and its concealment toward the western stairway if constructed without curvature (Figure 21.1). With the refinement of the stylobate's curvature, the diagonal view from the Sacred Way causes the curved lines to appear not parallel, but rather converging in two places (Figure 21.2). To avoid these conflicts, the architect refined this curvature by slightly raising the northwest and southwest corners.[17] In conjunction with these rises, he established the apex of the front's curvature at a point north of the temple's central axis (and west of the axis on the curved north flank), resulting in the final effect of a visually satisfying appearance of parallel linear composition (Figure 21.3).[18]

In contrast with these slight adjustments, the height of the cornice of the Parthenon rises only negligibly beyond a perfect 4:9 rectangle, despite the low

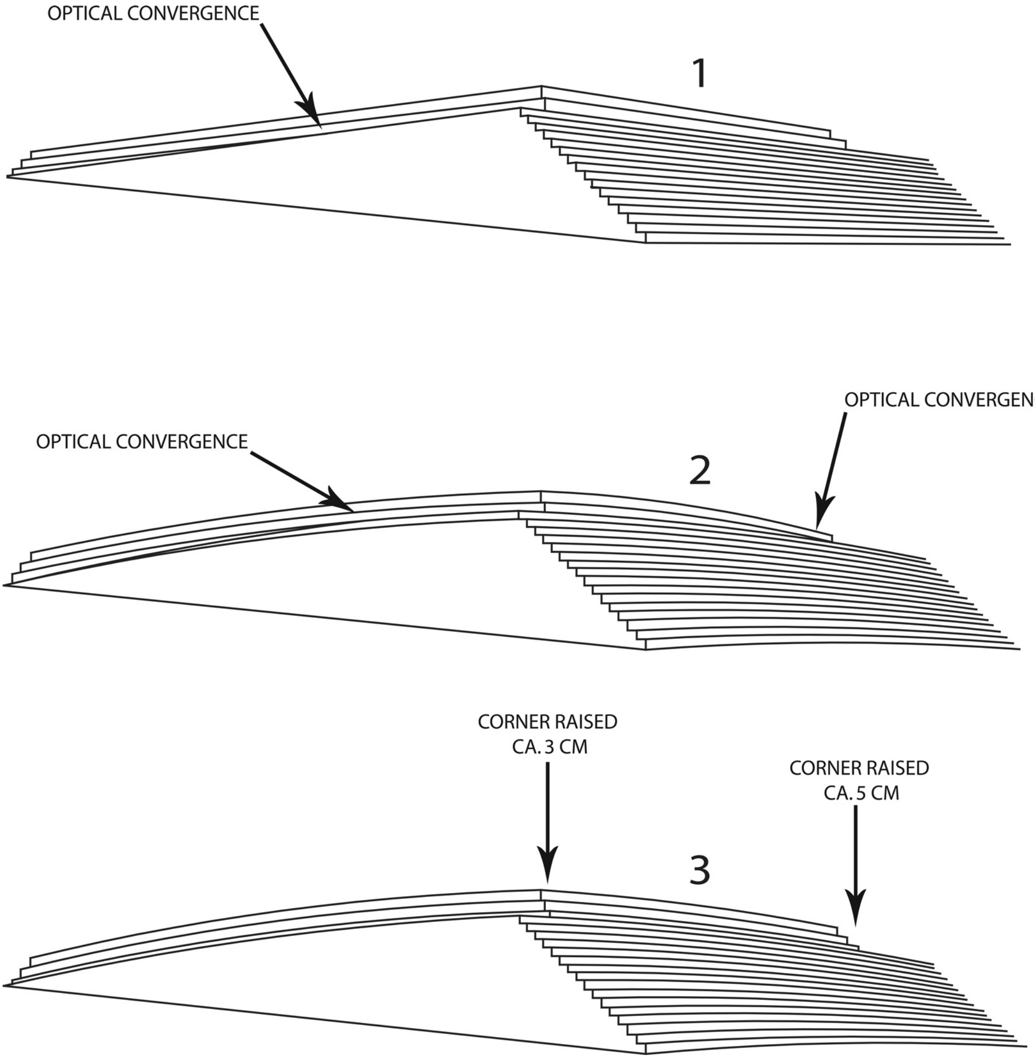


20 Parthenon, Athens. Refinements with horizontal curvature and extrapolated columnar inclination. Drawing author, adapted from M. Korres, in Korres 1999: Figure 3.29.

perspective from which it was usually viewed, and the Hephaistaion's 1:2 and 1:3 relationships actually fall a bit short of their ideal vertical dimensions, despite the main vantage point down in the Agora.[19] This lack of correction for optical experience suggests that architects did not intend such integral proportions as harmonies to be intuited visually, but rather as arithmetical frameworks within which to create a sculptural play of masses through concerns like the thickness of columns expressed through the tangible relationship of diameter to height.

The notion of Classical temple buildings as products of reduced-scale drawing also contradicts evidence suggesting that Greek architects traditionally understood such buildings as assemblages of clearly defined, repeated parts rather than as unified conceptions reducible to small-scale representations. Masons produced each individual part, such as a capital or triglyph, according to a 1:1 template called an *anagrapheus* or a 1:1 prototype or model termed *paradeigma* in wood, clay, stucco, or stone, and it was presumably the architect's responsibility to approve these models.[20] To bring it all together, the architect would provide and reference not drawings like our own graphic reconstructions (Figures 15 and 16), but written specifications known as *syngraphai*, which provided exact measurements for both individual elements and the distances that separated them.[21]

Along with this lack of necessity for reduced-scale drawings, there was probably little interest in advancing tools to aid in the very production of drawings. No measuring rulers survive, and scale-rulers undoubtedly did not exist.[22] Measurement on the drawing board would have depended on skillful use of a pair of dividers, and in order to produce accurate perpendicular and orthogonal lines, a straightedge would join circumferential intersections drawn with a compass.[23]



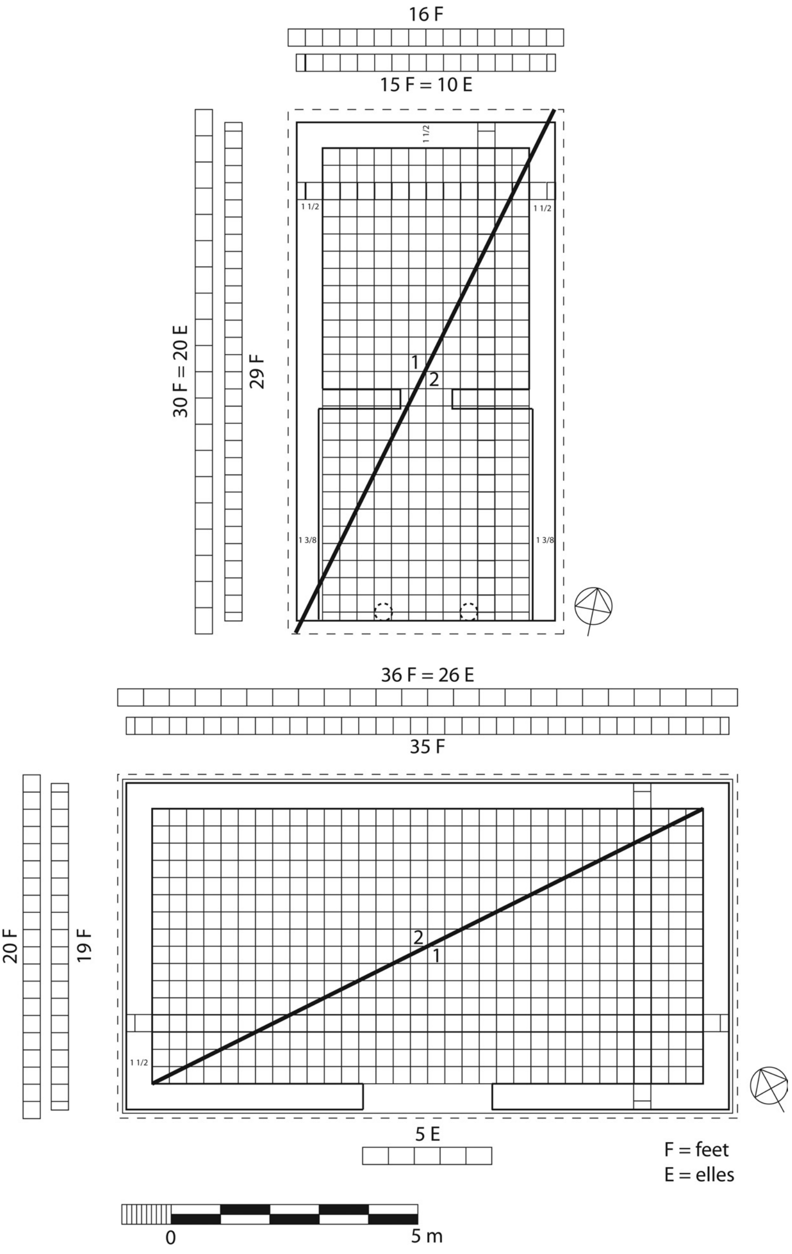
21 Parthenon, Athens. Analysis of viewer's perspective of the platform from the northwest, showing potential visual conflicts (1 and 2) and their adjustment through refinements (3). Drawing author, adapted from M. Korres, in Korres 1999: Figure 3.12.

Greek technical drawing with these simple tools doubtlessly achieved a level of sophistication that is largely lost on us today. Still, the relative lack of surviving textual and physical evidence for the development of Greek practices of drawing likely reflects a lack of urgency in aiding such a development.

The reasons for this circumstance are clear. With few exceptions, drawn plans would be little, if any, help in the planning or envisioning of traditional Greek forms as simple as rectilinear, colonnaded temples, stoas, and gateways.[24] As J. J. Coulton has induced, straightforward rules of thumb (with variations) would suffice to determine relationships between features as prominent in Doric design as the stylobate and columns.[25] With or without the aid of Vitruvius' testimony, it is also obvious that strict rules governed the interrelationships of elements in temple buildings, leaving little to explore in terms of establishing and combining forms in an elevation drawing. Beyond the question of prescribed proportional relationships of columnar width, height, and axial distances (*De architectura* 3.3.1–8), from the Archaic period forward, monuments repeated features of fixed sizes separated by fixed distances across the width or length of the building. Potential for much of the creativity in ancient Greek buildings thereby lay in the sizes and commensuration of typological forms repeated across friezes, the tops of columns, and so forth. Of course, theoretically one could carry out such designs with detailed elevation drawings as in the Beaux-Arts tradition, but this need not be the only effective method. The well-documented employment of full-scale prototypes of individual elements (*paradeigmata*) and written specifications (*syngraphai*), or even just plain on-site intuition as the construction progresses, would suffice for the total heights of features like columns or an entablature. What gives Greek buildings their unique character and presence, after all, is the plastic expression of their masses in three dimensions.[26] In developing such effects and conveying them to patrons and masons, only sculptural models of features would do. Perhaps anyone who has seen firsthand the subtly swelling echinus of the capitals, the curvature of the columnar shafts, and the crystalline projection of triglyphs in a mid-fifth-century building like the Hephaisteion (Figure 19) will agree that elevation drawings, let alone a ground plan, would contribute little to the aesthetic effect of its final product.[27]

Still, the view that traditional Greek buildings resulted from ichnography persists – a view that even includes works from as early as the Archaic period. The discovery of extensive chalk markings drawn at full scale on the foundations of Temple D of the sixth century at the Heraion at Samos are said to “prove” that the architect first drew at reduced scale before transferring his design to the actual dimensions on the foundations.[28] Yet it is unclear why the presence of a full-scale drawing in chalk that establishes the locations and extents of walls would indicate the use of a reduced-scale drawing any more than a temple that did not employ such markings. A complete 1:1 drawing would work as a guide for equal distances and wall thicknesses as construction progresses, but the drawing itself could follow written specifications at least as easily as a reduced-scale ground plan.[29]

Supposing that the technique was nonetheless common, metrological analyses of two other buildings of the sixth century where no chalk survives are cited as evidence of this three-part process of ichnography, conversion to full scale, and construction: The so-called Anta Building and East Building at Didyma.[30] Here, the thicknesses of walls and nearly all other dimensions conform to rational measurements in Ionic ells and feet, so much so that one may follow their excavator in showing their restored plans with overlaid grids indicating these measurements (Figure 22). The addition of such grids may enhance the


16 F
15 F = 10 E
30 F = 20 E
29 F
1 1/2
1 1/2
1 1/2
1
2
1 3/8
1 3/8
36 F = 26 E
35 F
20 F
19 F
2
1
1 1/2
5 E
F = feet
E = elles
0
5 m

22 Anta Building, Didyma (top) and East Building, Didyma (bottom). Sixth century B.C. Restored ground plans showing metrological analysis and related grid overlay. Drawing author, modified from P. Schneider, in Schneider 1996: Figs. 15 and 31.

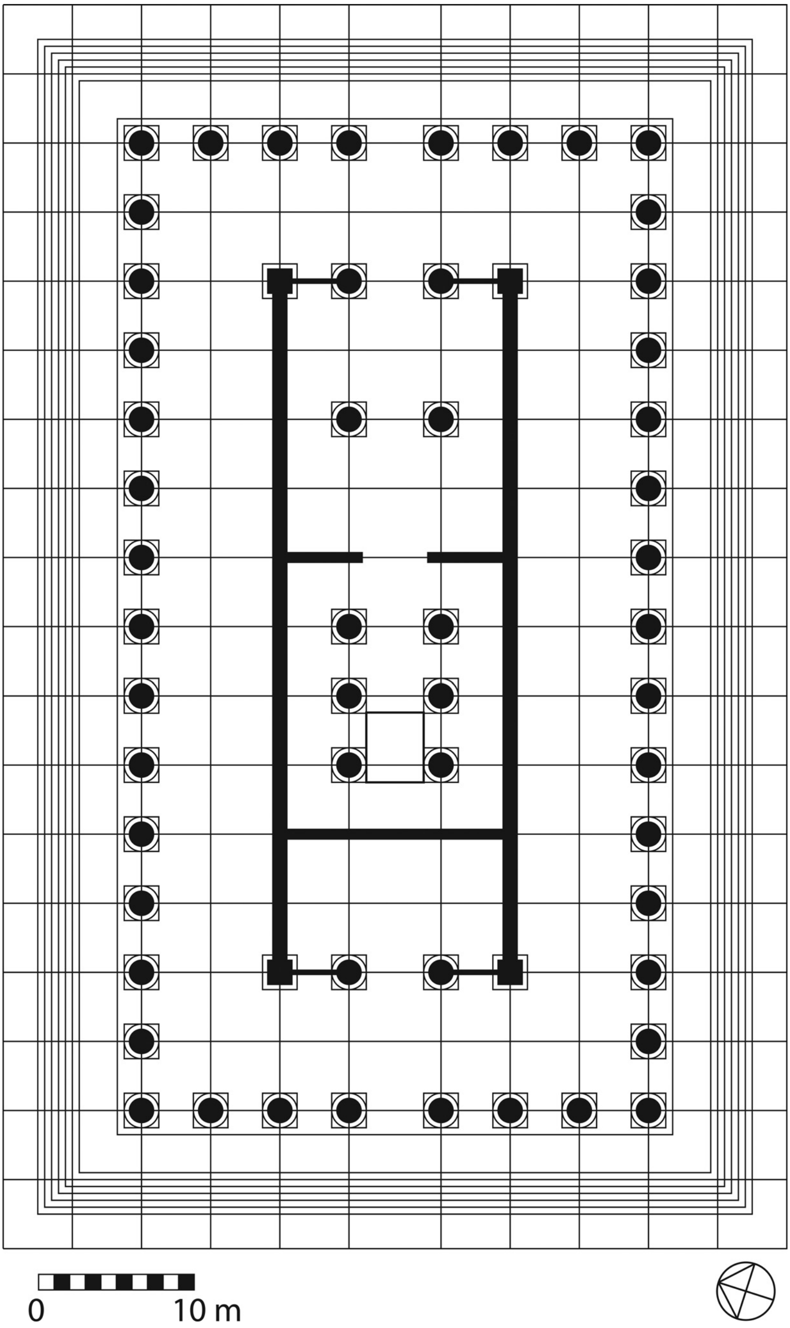
impression that the practice of ichnography established these ground plans, but in reality the grids are superfluous for any purpose other than clarifying for us the metrology at work in both the *x* and *y* dimensions. The impression of ichnography that these finely gridded plans convey depends perhaps on our familiarity with the T-square as a tool of modern technical drawing. T-squares were certainly used in ancient carpentry,[31] but there is no testimony for their use in ancient architectural drawing.

Also undermining our attempt to see scale drawing at work in these Archaic buildings at Didyma is the minimal *integration* – and not just conformity – of their proposed underpinnings and completed designs. In both examples, there is a notable lack of systematic integration of any interior features with the orthogonal network, leaving what one may describe as an "empty grid" that seems out of place with the expectation that a geometric underpinning should serve the positioning of concrete elements. Nor is this expectation necessarily a modern one; as our only surviving authority on Greek practices of architectural drawing, Vitruvius suggests a similar idea (*De architectura* 1.1.2–4). He describes ichnography as the use of the compass and straightedge to embody *taxis* (Lat. *ordinatio*) as a process of ordering by imparting *posotes* (Lat. *quantitas*) or "quantity" in the creation of modules within the work, as well as design or *diathesis* (Lat. *dispositio*) as a process aiming at elegance through graphically placing features within the work. Together, this ordering and placement result in the principles of *symmetria* (modular commensuration) and *eurythmia* ("good shape"). Although the buildings at Didyma reflect nothing antithetical to this description, their simplicity does not readily suggest the unification of features and principles through the processes of Greek drawing known to Vitruvius.

By contrast, the Hellenistic Artemision at Magnesia by Hermogenes (late third century) and the Late Classical Temple of Athena Polias at Priene by Pytheos (ca. 340) show extensive and consistent integration with the grid as a graphic underpinning (Figures 23 and 81).[32] In both examples, the grid expresses modular quantity that serves the systematic placements of columns and walls. Furthermore, with respect to the restored plans of the Archaic buildings, the grids at Magnesia and Priene are reduced to a minimum number of dividers, a construction that appears more in line with the compass and straightedge as opposed to a T-square, although even here their correspondence to ancient drawing is far from conclusive. In Chapter 4, I consider additional literary, epigraphic, and archaeological evidence to analyze these two later temples as possible products of ichnography. For the moment, this brief comparison should underscore the relatively weak case for ichnography represented by the Archaic buildings at Didyma.

THE STRANGE CASE OF ICHNOGRAPHY

Despite their ubiquity in the modern world, the limited utility of reduced-scale architectural drawings in the Greek world may provide us the opportunity to contemplate the fundamental peculiarity of ichnography in particular. Arguably, there is an important conceptual distinction between elevation or perspective drawings on the one hand and ground plans on the other. The very



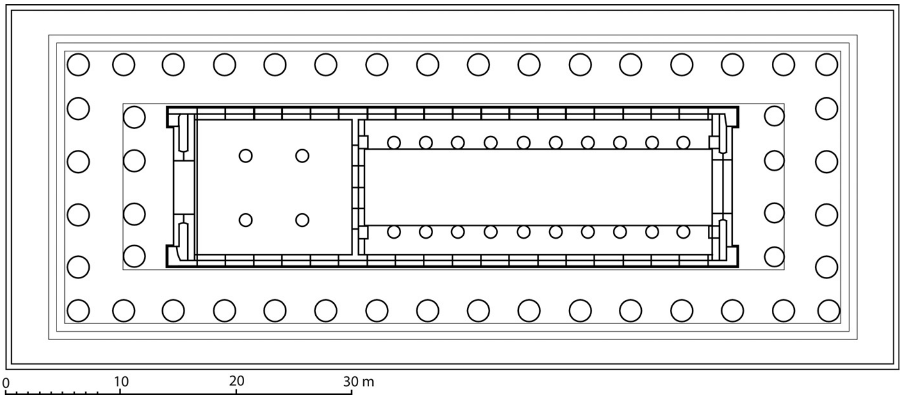
23 Hermogenes (third and second centuries B.C.). Temple of Artemis Leukophryne at Magnesia-on-the-Maeander. Begun ca. 220 B.C. Ground plan. Drawing author, modified from J.J. Coulton, in Coulton 1977: Figure 23.

concept of orthographic projection as given in elevation drawing is artificial enough, given its tendency to flatten all features onto a plane without the foreshortening that occurs in usual visual experience. Yet one must appreciate the feat of imagination represented by the invention of ichnography as the concept of a building represented not in part as the eye sees it, but rather in its entirety as seen at a unified and consistent scale from the almost unfathomable viewpoint of directly above, and at the same time showing only those features that come into contact with the supporting plane.

Easy justifications for the practice may be made, though with reservations. Aerial views were certainly a part of visual experience in all periods of the ancient Greek world, as in surveillance taken from mountaintops during military campaigns. Still, it is difficult to reconcile the ground plan of a temple with a natural mode of seeing where walls and roofs create invisible barriers. Although one may envision a scenario in which builders arrived at the idea of ichnography while viewing the relationships between a temple's interior and exterior features as they stood on partially constructed walls, this scenario itself places the temple's construction before the builder's apprehension of it in plan. Of course, one could also posit that such a "eureka moment" took place relatively early and was applied to later buildings at the outset of their designs. Then again, one may question the value of deferring to such a defense for the early practice of ichnography. A rigorously skeptical approach to the question of ichnography may help us identify more securely the instances of its application, thereby allowing for a fuller appreciation of what these individual cases can tell us about the genesis and nature of the practice.

To emphasize this discordance between natural vision and ichnography is not to exclude the possible existence of the latter at any point in the chronology of ancient Greek architecture. The earlier practice of ichnography in other ancient cultures is a well-established fact, and Greeks were in regular contact with the larger world since the Ionian military and commercial involvement in Egypt in the seventh century.[33] Furthermore, a small sketch of a building from an aerial perspective showing its internal and external features may not be beyond the capabilities of even a highly creative child in any era. Yet to apply this imaginative view to the making of an actual building, there would need to be both a motivation for its use and a method of application consistent with the tools and procedures with which Greek architects worked. In light of both the sculptural emphasis of Greek temples and the efficacy of *syngraphai*, in most cases the motivation for ichnographies would not be easy to support.

In addition to their inherent strangeness as aerial views, there is an obvious – though important – quality that separates ichnographies from the other types of reduced-scale drawings practiced in classical architecture.[34] Other drawings address experience at a sculptural level, representing the composition of masses as they appear to the eye from either a specified vantage point (perspectives) or

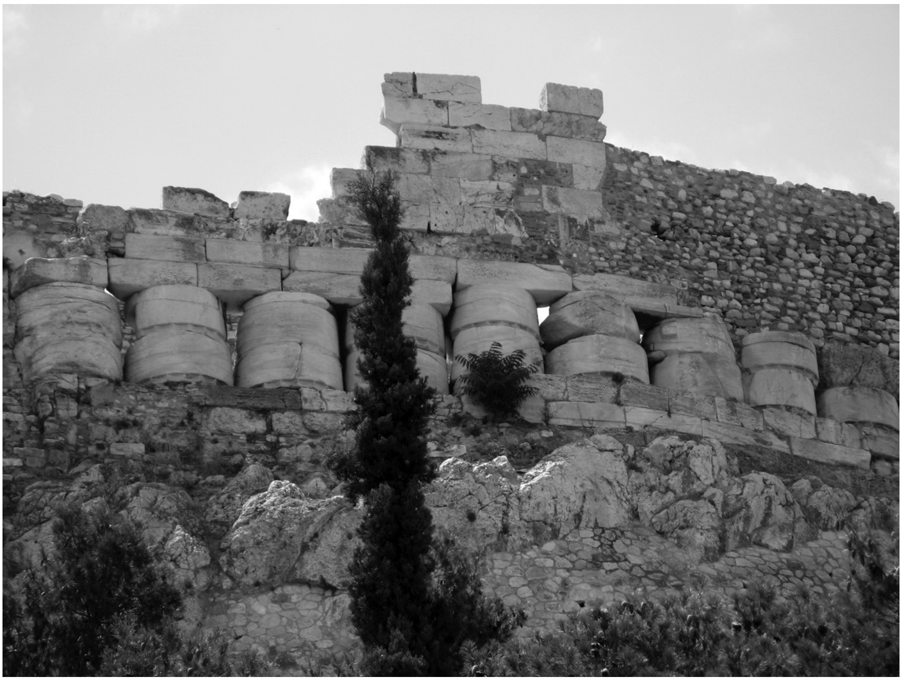


24 Archaic Parthenon, Athens, 490–480 B.C. (in progress when destroyed). Ground plan. Drawing author, modified from M. Korres, in Korres 1994: Figure 1.

generalized frontal view (elevations). Ichnographies, on the hand, leave aside the optical qualities of architecture. Instead, they are limited to fixing the relative planar positions of the edges and centers of features, as in walls, doorways, and columns. Their operation concerns the establishment of an abstract spatial order through relationships that are purely two-dimensional. Such a planar conception of space constructed with the compass and straightedge is clearly needed to design buildings of complex polygonal or round outlines, as in Roman Imperial or Byzantine architecture, but the utility of its application in simple prismatic Greek buildings seems difficult to justify.[35]

The Parthenon's Ground Plan

In coming to terms with this difficulty, it may be helpful to embrace a full range of complications by looking at the Classical Parthenon of 447–438, whose ground plan on the level of the stylobate may be the most innovative and complex of any Greek temple of the Classical period.[36] Its architect, Iktinos, faced the special challenge of creating a truly monumental (more than 72 × 33 m on the krepis) and spacious temple of the Doric order while incorporating the foundations and marble column drums of the hexastyle Archaic Parthenon (Figure 24) destroyed by the Persians in 480 (drums and ashlar blocks too damaged to reuse were newly incorporated into the north wall of the Akropolis – see Figure 25).[37] Despite the constraint of including column drums of a predetermined diameter, Iktinos designed a ground plan (Figure 2) with a notably wide cella capable of accommodating 1) the monumental chryselephantine cult statue of Athena Parthenos by Pheidias, surrounded on three sides by an unprecedented interior pi-shaped colonnade; 2) unprecedented yet geometrically pleasing proportions between the respective widths of the naos and the overall plan; and 3) a precise alignment of the antae of the pronaos with the outer columns.[38] Furthermore,

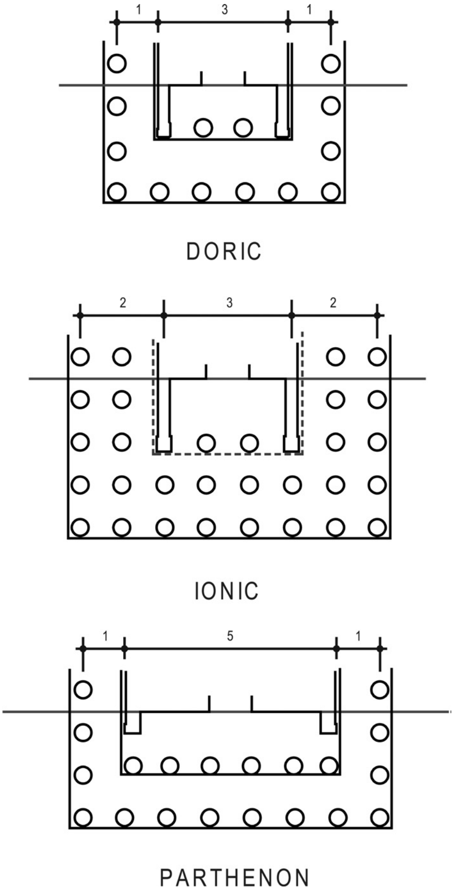


25 Akropolis, Athens. Columnar drums and ashlar blocks of the krepis of the Archaic Parthenon, built into the north wall following the Persian destruction of 480 B.C. Photo author.

the architect achieved all of this while maintaining rational proportions shared by select planar masses and their intervals – the well-known 4:9 ratio between the lower diameters of the columns and their axial distances – as well as in the large-scale width-to-length dimensions of the stylobate (again, a 4:9 ratio).[39]

Might such a combination of innovation and visual clarity indicate that Iktinos worked through the composition of the Parthenon's stylobate and supporting features by way of ichnography? A legitimate rejection of this possibility used to be the limited size of available drawing surfaces like papyrus, a clay tablets, or a whitened board (λεύχωμα).[40] Following the discovery in 1979 of the Hellenistic blueprints incised into the walls of the adyton of the Didymaion (Figure 33), however, this objection is no longer tenable.[41] Theoretically, Iktinos could have drawn plans on the large surfaces available on the very blocks of the destroyed Archaic Parthenon at the site of construction.

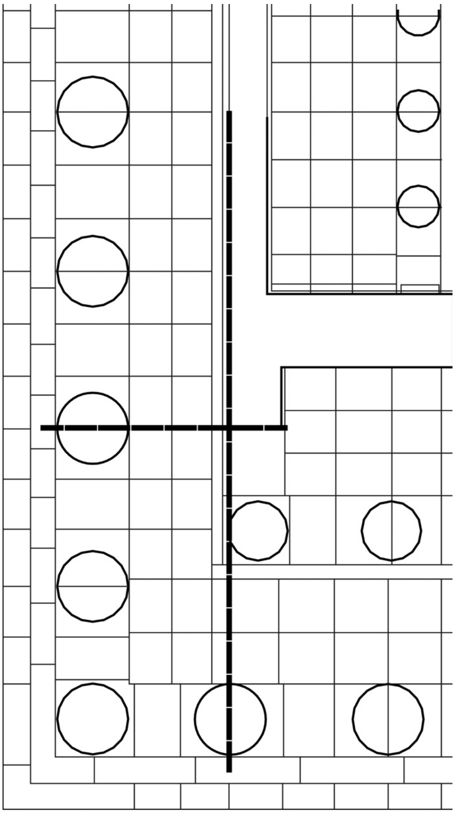
In terms of the relationship of its naos to its overall width, the Parthenon represents a significant departure from earlier temples (see Figure 26). Traditional Doric temples are hexastyle with a 1–3-1 tripartite relationship of the lateral ptera and naos, divided according to the five axial distances of the front.[42] Traditional Ionic temples, on the other hand, are octastyle dipteral arrangements with a 2–3-2 tripartite relationship according to seven axial distances. Yet despite its Doric order, the Parthenon adopts the octastyle arrangement of Ionic



26 Schematic comparison of typical plans of Doric hexastyle and Ionic octastyle temples with the Parthenon. Drawing author, modified from M. Korres, in Korres 1994: Figure 35.

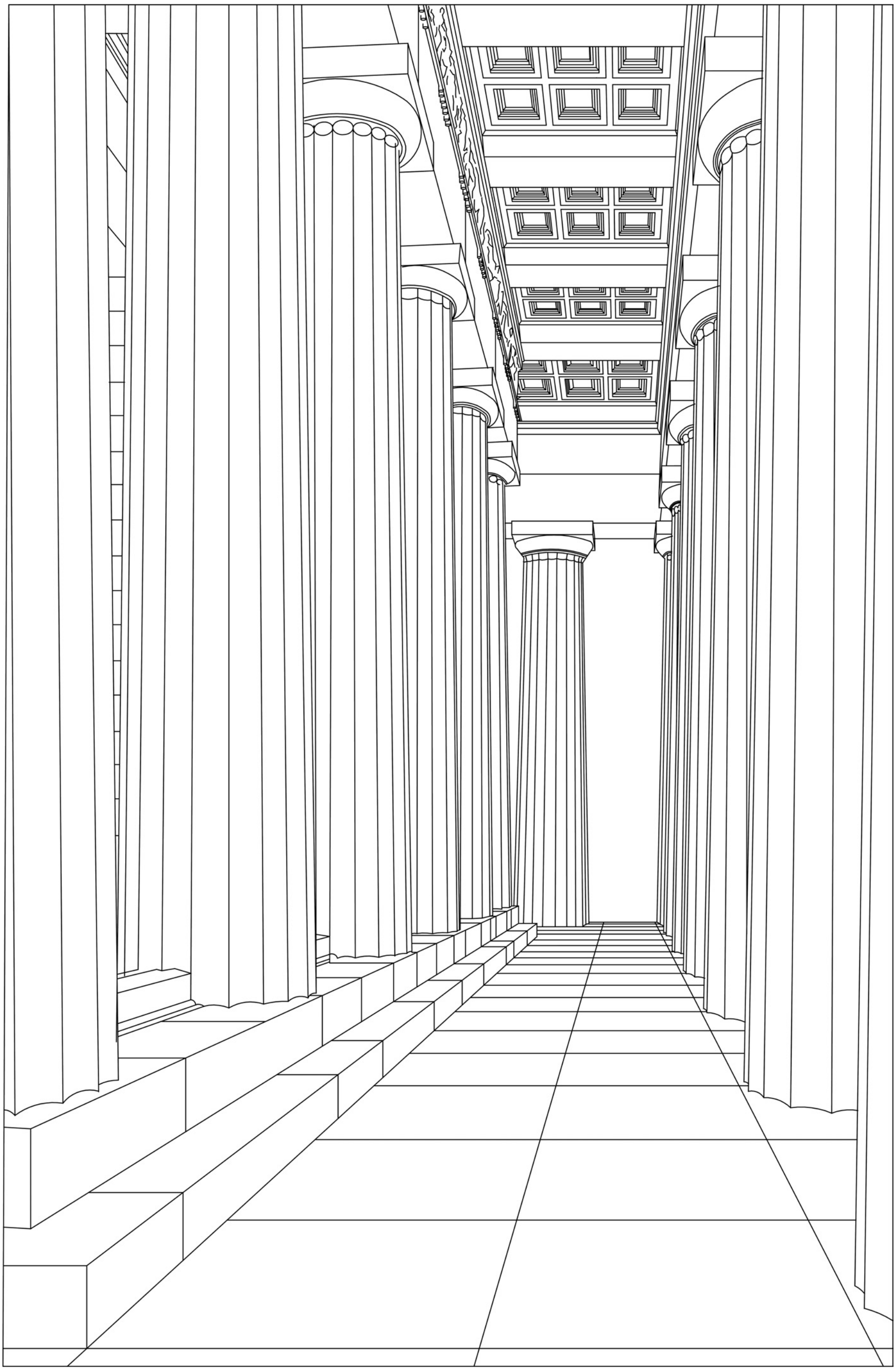
temples while extending the relative breadth of its naos to create an unprecedented 1–5-1 relationship, or about 70 percent of the total width.[43] At the same time, this correspondence between the naos and the columns is given an almost graphic clarity through the alignment of the antae of the pronaos with the axes of the second and third columns from the corner – the so-called "rule of the second column" (Figure 27).[44] Finally, these proportional and axial features are given the precision of integral ratios. Although Iktinos worked with the preestablished column diameters of the Archaic Parthenon, these diameters establish a 4:9 ratio with the axial distances. It would even appear that this same 4:9 proportion reflects in the overall width-to-length dimensions of the stylobate.[45]

Even though these planar features do indicate careful considerations of design, they would in no way depend on reduced-scale drawing. As discussed earlier, proportional relationships like the 4:9 ratio of the columns to the axial distances were common schemes that could have been easily communicated orally or in writing. Arguably, the visual representation of this relationship at reduced scale would involve a step that unnecessarily complicates the design process. As for the correspondence of this same ratio to the overall rectangle



27 Parthenon, Athens. The so-called "rule of the second column," resulting in the axial alignment of the antae with the second and third columns. Drawing author, modified from M. Korres, in Korres 1994: Figure 38.

of the stylobate, a simple procedure unrelated to drawing makes this possible: the strong contraction of the corner axial distances in order to cope with the famous "corner triglyph problem" (Vitruvius 4.3.2).[46] In addition to correcting the potentially excessive widths of the lateral metopes, which would otherwise result from the placement of the corner triglyphs beyond the axis of the corner columns, the contraction controls the length and width of the stylobate to maintain the 4:9 ratio. A planar drawing of this 4:9 rectangle would not even be helpful in envisioning the stylobate's appearance because, owing to colonnades and walls, the stylobate as a whole would never be a part of any viewer's optical experience. Furthermore, despite the suggestion of a graphic sensibility in the "rule of the second column" (Figure 27), this feature is actually a common element of fifth-century design and arguably founded on optical, three-dimensional rather than planar considerations: The alignment of the antae with the axes of the third columns on the northern and southern flanks increases the density of columns in the corners, placing the second column on each flank so that its mass provides a sense of enclosed space in the eastern or western ptera. For an observer inside the western pteron, the second column visually affirms the continuity of the colonnade-framed space around the cella (Figure 28).[47] In addition, this canonical alignment of the antae with the columnar axes



28 Parthenon, Athens. Restored perspectival view of the western pteron. Drawing author, modified from A.K. Orlandos in Korres 1994: Figure 40.

controls the breadth of naos without the need for exploring its relationship with the overall width graphically at reduced scale. Considerations like these do not prove that the Parthenon's architect did not draw scale ground plans. They do, however, demonstrate that even this most spatially intricate and inventive of Classical period temples makes a weak case for their necessity in creating the final building.

ALTERNATIVE JUSTIFICATIONS FOR ICHNOGRAPHY

Still, one may consider a separate possibility. To suppose that visual experience alone justifies a method of design perhaps presupposes that the value of experience trumps the value of other possible motivations in the creation of a building. For us, for example, there is one value in particular that the construction of architectural space does not necessarily depend on, and which justifies ichnography and makes it seem natural. Rather, it is pressed upon by the very tradition of institutionalized formal training: The value of expectation. In design studio reviews in modern schools of architecture, one frequently finds a rote expectation that students present ground plans along with other scale drawings and models. Through this kind of unreflective reinforcement, the practice of presenting ground plans continues in professional practice, particularly in architects' presentations to clients. Might there have been a similar, not strictly design-related motivation for ichnographies in the Classical period?

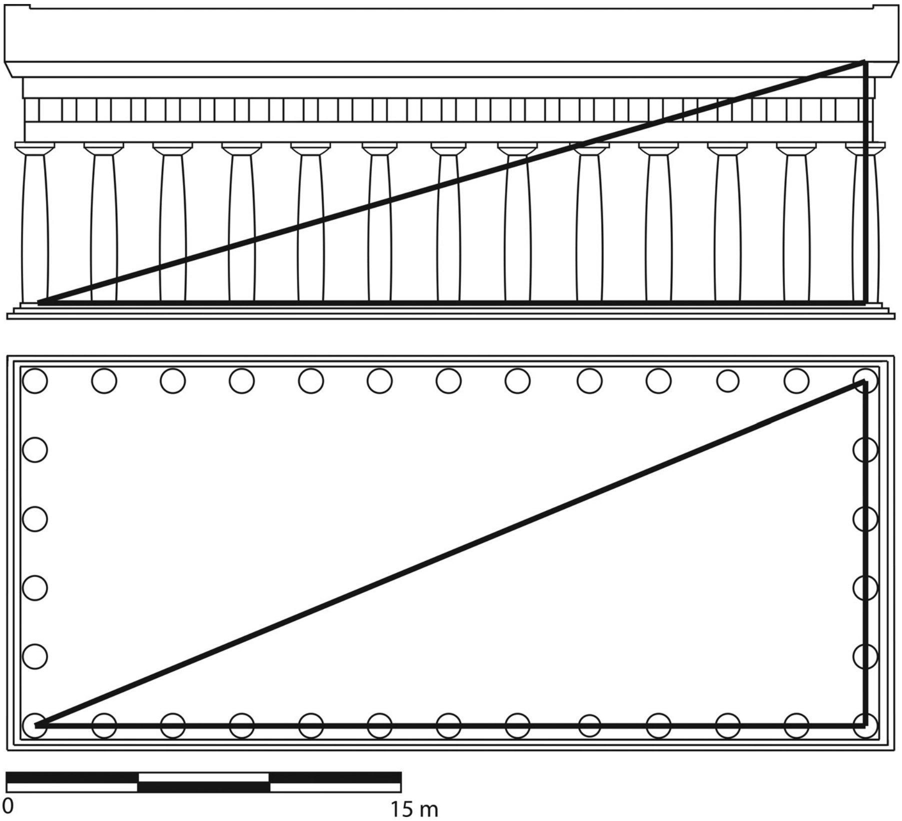
Keeping in mind obvious cultural differences between modern architectural practices and those of ancient Greece, one possibility worth exploring is the value of ichnography for contemporary Greek thought. Consistent with the moral and spiritual value of Classical Greek art advocated by Pollitt,[48] such value may emerge from the creation of works that address concerns at an abstract level through their faithfulness to truth or reality as opposed to bodily experience or perception.[49] According to Vitruvius, Greeks called their architectural drawings *ideai* (ἰδέαι),[50] a term that shows a parallel with the Platonic notion of transcendent, universal, and archetypal Ideas that are imperfectly imitated in the images of nature.[51] Such *ideai* ultimately relate to "the Idea of the Good" (ἡ τοῦ ἀγαθοῦ ἰδέα , Plato *Republic* 508e) that illuminates the intelligible realm. In the phenomenal realm, the Idea of the Good is the source of the sun itself and its illuminating power and all that is right, beautiful, and true (517b-c). This kind of philosophical idealism is distant from the Kantian notion in which the cognitive apparatus intuits the world through space as a perceptive mode separate from pure objects (or *noumena*).[52] Rather, Platonic idealism is couched in terms of mimesis, wherein the production of a physical object proceeds from the craftsman's apprehension of the abstract, disembodied shape of the ἰδέα or εἶδος, which he then imitates in physical form: "For of course no craftsman crafts the *idea* itself" (οὐ γάρ που τήν γε ἰδέαν αὐτὴν δημιουργεῖ οὐδεὶς τῶν δημιουργῶν, 596b).[53]

Plato's deferral to craftsmanship in the effort to explain the character of transcendent Ideas indicates that, as a concept, they need not have been entirely unprecedented. Significantly, Plato has Sokrates say: "And are we not accustomed to say (εἰώθαμεν λέγειν) that the craftsman . . . directs his eyes to the *idea* and thereby makes the couches on the one hand or the tables on the other, and other things that we use?" (*Republic* 596b). Here, Plato seems to suggest that it is commonly recognized that *ideai* belong also to craftsmanship, and that in the world of making the term conveys the more straightforward meaning of "idea" (with a lower case "i") that survives as its common meaning in modern Greek.[54] In other words, the *ideai* of Plato may represent the adoption of a common term as a metaphor to describe his metaphysically charged notion of transcendent, intelligible reality.

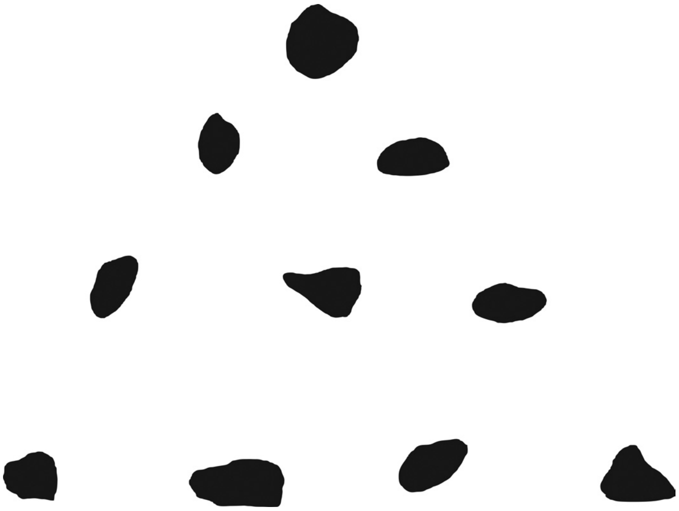
Particularly when introducing the *ideai* in the *Republic*, their common meaning as mental ideas or images has not been separated from the Ideas (with a capital "I").[55] In craftsmanship, these *ideai* need not have taken a graphic component for makers of couches and tables who might have envisioned their product and carried them out accordingly. In the case of architects specifically who required their builders to see their ideas, however, it makes sense that the term might have been adapted for drawings. As elaborated later in this chapter, this possibility may explain Vitruvius' reference to reduced-scale architectural drawings as *ideai*.

If such drawings existed even before Plato, one may ask whether there existed a tradition that may have understood them to carry some value of essential good, beauty, or truth, thereby establishing a meaningful precedent for Plato's notion of the Ideas. As early as the late sixth century, in fact, there is an example that should call attention to the possibility. Analysis of the Temple of Athena at Paestum in southern Italy has revealed interesting arithmetical and geometric features in both plan and elevation (Figure 29).[56] In elevation and plan, Pythagorean triangles underpin the temple's design.[57] Measured in feet, significantly, the sum of all three sides in plan equal 240, which is the product of ten and twenty-four. In Pythagorean thought, ten is the *teleion*,[58] the perfect number because it is the sum of one, two, three, and four – the first four integers that make up the sacred *tetraktys* (or decad) that is easily formed by ten pebbles (Figure 30). This was the symbol by which adherents swore by Pythagoras.[59] Similarly, twenty-four is the product of the integers of the *tetraktys*.

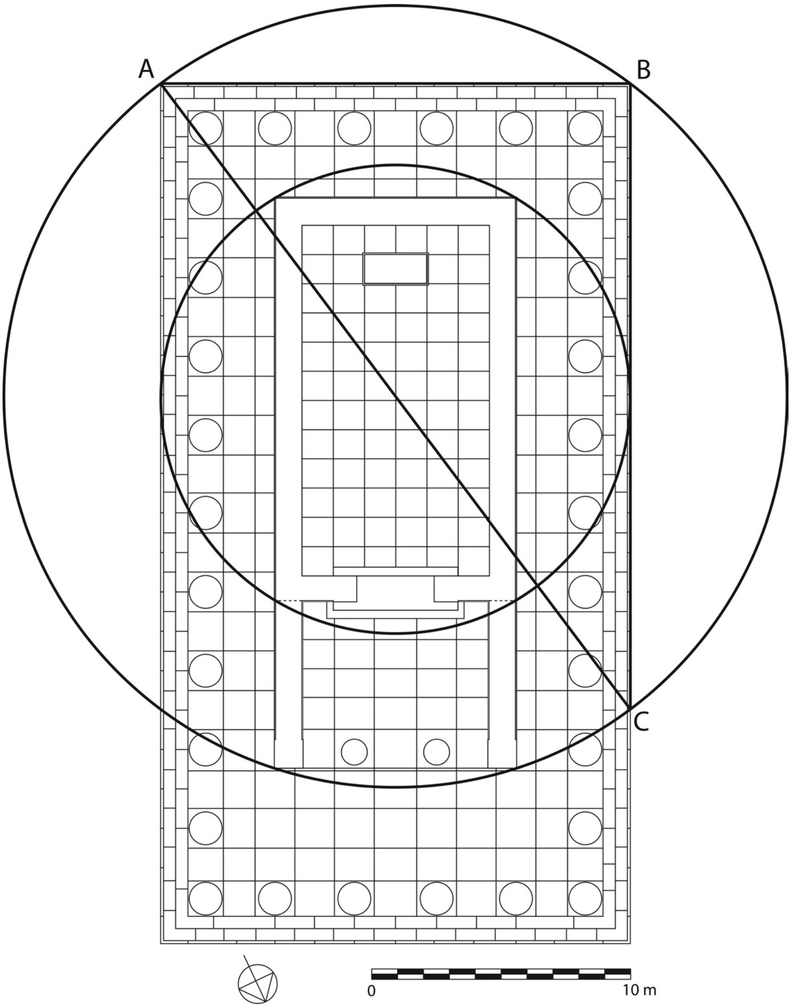
A new analysis of Temple A at the Asklepieion at Kos of ca. 170 shows analogous results in a Doric temple of the Hellenistic period (Figures 31, 32).[60] As demonstrated through AutoCAD and analytic geometry, integral relationships are established circumferentially in addition to orthogonally. With the overall width-to-length proportions equal to 6:11, circles with diameters sharing a ratio



29 Temple of Athena, Paestum (ancient Greek Poseidonia). Late sixth century B.C. Restored elevation and simplified ground plan (naos omitted) showing underpinnings of Pythagorean triangles. Drawing author, modified from R.A. Baldwin, in Nabers and Ford Wiltshire 1980: Figs. 1, 2.



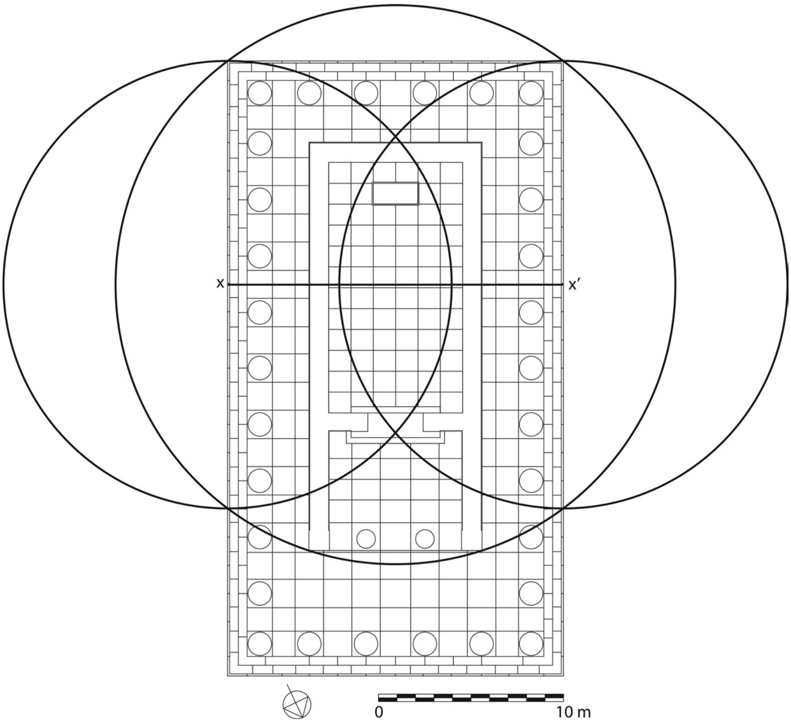
30 The symbol of the tetraktys by which adherents swore by Pythagoras, expressing the sacred sum of 10 (the *teleion*) from the first four integers, here formed by pebbles. Drawing author.



31 Temple A, Asklepieion, Kos. Begun ca. 170 B.C. Restored ground plan showing geometric underpinning of 6:8:10 Pythagorean triangle *ABC* and 6:10 ratio of diameters establishing locations of the cella and pronaos. Drawing author.

of 6:8 locate prominent corners and walls according to a 6:8:10 Pythagorean triangle.[61] Here, the sum of the triangle's sides again equals twenty-four, the product of the integers of the *tetraktys*.

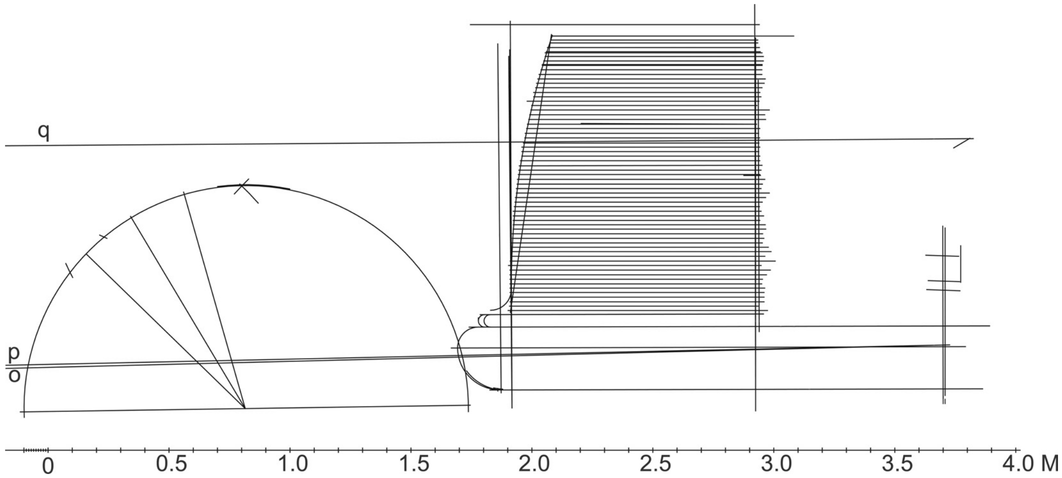
A major difference between these Archaic and Hellenistic examples is their relationship to the question of drawing. In positioning architectural features systematically according to circles and whole-number quantities that define a regular polygon, Temple A anticipates Vitruvius' envisioning of temple design (3.1.2–3) through the analogy of nature's creation of the human body (Figure 11), as well as his account of architectural *ideai* in terms of *taxis*, the process of ordering based on quantity, and *diathesis*, the process of positioning features in accordance with that *taxis* (1.2.1–3).[62] In this way, Temple A is like the temples



32 Temple A, Asklepieion, Kos. Ground plan showing geometric underpinning of circumferences with radii of four and five units centered on baseline x-x′, with intersections establishing perpendicularity and the locations of the euthynteria and antae. Drawing author.

of the Ionic order by Pytheos and Hermogenes (Figure 81) wherein the modular grid controls the placement of main features, although the nonorthogonal nature of Temple A's *taxis* of circular diameters highlights even more the practice of compass-drawn curves as found in the Didyma blueprints, for example (Figure 33). Whereas the circumferential relationships of Temple A demonstrate a conception that can only have resulted from the tools of technical drawing, then, the architect at Paestum could have conceived of his ground plan by way of number rather than drawn geometry that was ever *seen*. If for the moment one suspends skepticism, however, the Temple of Athena possibly suggests that, as early as the Archaic period, geometric drawings as "ideas" for plans and elevations might have conveyed meaning and beauty that existed independently of the corporeal constructions they projected.

This chapter's analysis of just a handful of Greek buildings establishes a consequential inference. Temples dated to before the fourth century period may *suggest* the application of ichnography in their designs. Ultimately, however, our difficulty in establishing the necessity of ichnography in their creations undermines our secure identification of the craft of scale drawing at work. The ground plan of the High Classical Parthenon certainly shows sophistication and



33 Hellenistic Didymaion. Restored working drawings for the fluting of column drums and the construction of columnar entasis discovered on the adyton walls. Drawing author, modified from L. Haselberger, in Haselberger 1980: Figure 1.

complexity. Yet like the Archaic buildings at Didyma, it nonetheless differs from the interdependence of concrete features and theoretical underpinning expressed through the grid that graphically unifies the walls and columns of the Late Classical Temple of Athena Polias at Priene, for example. Likewise, the geometry of something like a Pythagorean triangle in the Temple of Athena at Paestum offers the intriguing suggestion of a graphic underpinning in the Archaic period. Still, this suggestion lacks the force of Temple A at Kos in the Hellenistic period, where the Pythagorean triangle relates to circles that appear to locate features according to the compass and straightedge, the tools of architectural drawing. In these ways, one must admit that a correlation between the final form and the hypothetical role of drawing discernible in Late Classical and Hellenistic temples is less apparent, and therefore less convincing, in the temples of the sixth and fifth centuries.

Nonetheless, a second inference excludes easy dismissal of the value of scale drawing in the creation of Greek temples before the fourth century. Regardless of whether one seeks salient reflections of the tools of drawing or conform one's understanding of ichnography to the procedures of *taxis* and *diathesis* described by Vitruvius, an important connection between the Archaic and Hellenistic temples at Paestum and Kos remains: Both seem to feature an underpinning of a Pythagorean triangle with the *tetraktys*. One may wonder if the more thorough level of *integration* of geometry, number, and built form exemplified in works of Pytheos, Hermogenes, or the anonymous architect of Temple A at Kos is as much a litmus test for the Late Classical emergence of scale drawing as it is, conceivably, a development on traditions of drawing of greater antiquity. In other words, a requirement that practices observable in relatively late Greek buildings and described by Vitruvius demonstrate the earlier existence of scale drawing would depend on two unverifiable assumptions: That the integrated correspondence between *taxis* and *diathesis* was not simply a later innovation, and that the primary purpose of architectural *ideai* was always the shaping of buildings rather than some other motivation.[63] As such, the possibility remains that a long-standing primary value of *ideai* in at least some examples of the craft of building could have been their association with views that had their origins in Pythagorean thought or some other interest in number and archetypal geometric form.

There is, in fact, an attractive reason to consider this alternative possibility. Based on good evidence, Coulton eloquently argues that architects of the Archaic and Classical periods were *not* master craftsmen who learned their trade through apprenticeship and worked their way up the ranks of stonemasons.[64] Rather, they were educated men of independent means who learned the art of building through reading technical treatises that they also, of course, wrote. Motivated not by the need for earning a wage, they designed buildings and directed their construction to earn prestige by contributing to their respective communities. This characterization of Greek architects is consistent with observations in Plato's *Statesman* that architects direct manual workers while they themselves are not manual workers, that they produce knowledge and not manual labor, and that they belong to a proper intellectual milieu (259e).

If such was the case, it would be conceivable that ichnography might have emerged and for some time endured not only as a practical starting point for the planning of buildings, but also as an expression of erudition, perhaps associated with qualities like beauty and truth. In this scenario in which ichnography originated in concerns other than those of pure craftsmanship, it would also be tenable that it was only later that, rather than mere embodiments of number and geometry, scale ground plans acquired more of the mark of craftsmanship in expressing the tools and techniques that appreciably shaped them and the buildings they projected. If so, in temples like those at Priene, Magnesia, and Kos, the clear integration of underlying graphic constructions, concrete forms, and formal interrelationships would represent a notable development – and not the new invention – of ichnography in the Late Classical and Hellenistic periods. As such, the possibility that the Archaic and Classical precursors of these later buildings reflect practices of ichnography nonetheless remains.

In exploring the merits of this possibility, we are likely at an impasse in looking solely to buildings, however. Instead, one would do better to turn to the literary record in order to engage the following questions. Might ichnography have been born of abstract thought, reflecting an intellectual or spiritual value held by architects who, as educated people, cultivated it through engagement with philosophical matters rather than concerns of building? Along with thinkers belonging to Pythagorean traditions, might architects of the sixth and fifth centuries have anticipated Plato's *ideai*? If one allows for the possibility that *ideai* as architectural drawings extend back into traditions preceding Plato, one may begin to analyze Plato's writings as reflecting traditions of the art of building.

NUMBER, GEOMETRY, AND SEEING

As Pythagorean creations, the application of number and geometry in design possibly anticipated Plato by imparting a spiritual dimension to the process of making.[65] Plato writes that number brings one into the light of truth and that "geometry is knowledge of eternal being" (τοῦ γὰρ ἀεὶ ὄντος ἥ γεωμετρικὴ γνῶσίς ἐστιν, *Republic* 527b).[66] Elsewhere, Sokrates draws geometry as a demonstration of innate and universal truth (*Meno* 82b–86c). The qualities of number and geometry involve considerations of not only shape, then, but also the element of disembodied truth that is verifiable through reason.[67] Furthermore, this moral value impacts aesthetic considerations as a requirement for beauty or fineness (τὸ κάλλος): Measure (μετριότης) and commensuration (συμμετρία) are to be identified with both beauty and excellence (*Philebus* 64e),[68] and Plato specifically describes geometric forms as beautiful (*Timaeus* 53e–54a), or even exemplary of absolute beauty in the sense of beauty in itself (καθ᾽ αὕτά) without dependence on a functional or aesthetic relationship to anything else (*Philebus* 51c-d).[69]

Properly speaking, this sense of beauty is not readily conveyed or experienced in paintings, sculptures, and buildings.[70] On the contrary, it is problematic for embodied experience. For example, earlier I objected to the value of a drawing that helps envision the 4:9 proportions of the Parthenon's stylobate, since the presence of colonnades and walls obstructs the viewer's apprehension of this plane as a distinct spatial entity. For Plato and his Pythagorean precursors, possibly, the value of such proportions in this context would not even be in their visual experience.

After all, Plato clearly distinguishes between two kinds of mimesis: 1) colossal sculptures and paintings of Plato's own time that are mere phantasms (φαντάσματα) featuring proportional adjustments for the sake of correctness of appearance from an observer's lower vantage point; and 2) those older works that were images (εἲχούς) imitating "the commensurations of the model (or ideal)" (τὰς τοῦ παραδείγματος συμμετρίας, *Sophist* 235d).[71] Which of these two approaches Plato privileges is made clear by his artistic ideal of "the true commensuration of beautiful forms" (τὴν τῶν καλῶν ἀληθινὴν συμμετρίαν, 235e) that, metaphorically, stands in opposition to the deceit of the sophist. Beauty lies not in the optical perception of the large-scale work, but rather in the pure geometry of the model, a preference that Plato also echoes in his privileging of geometric forms over paintings and organic objects (*Philebus* 51c).

For Plato, then, beauty is aligned with truth in geometry and number rather than common visual experience – a concept that carries important implications for the possible value of the *idea* as a graphic model.[72] On the one hand, beauty may be present in a work by virtue of its correctness (ὀρθότης) in imitating its model, relating to art's pedagogic function of suggesting the existence of the Ideas.[73] On the other hand, beauty and virtue may exist independently by the work's own internal nature (κατά φύσιν, *Republic* 444d) and as a product of measure and commensuration in its constitutive parts (*Philebus* 64e, *Republic* 444e) that define its order or *taxis* (or οἰκεῖος κόσμος, *Gorgias* 506e).[74] Along with music, dance, poetry, painting, and embroidery, for Plato, the art of building can directly imitate the Ideas through good shape or *eurythmia* (*Republic* 400e–402b).[75]

In examining this relationship between beauty and truth, it is important that one distinguish between what one may call *common* visual experience and the experience of vision that is properly directed or engaged with the proper objects. To be sure, Plato clearly states that the Ideas cannot be seen (ὁρᾶσθαι, *Republic* 507b). Nonetheless, he repeatedly describes the apprehension of the Ideas in terms of vision (θέα or ὄψις) and as objects for the soul to view or look on (ἰδεῖν, βλέπειν, ἀποβλέπειν, κατιδεῖν).[76] In other words, embodied seeing and the understanding of this kind of seeing serve as Plato's metaphor for describing the soul's encounter with the Ideas, just as the craftsman of couches or tables serves as the metaphor for Plato's divine craftsman of the universe (*Republic* 596b), or the *ideai* of craftsmen provide a model for understanding of transcendent archetypes. He describes "the soul's vision" (τῆς ψυχῆς ὄψιν, 519b) or a kind of vision that may be properly directed through number, which allow the soul to see (ἰδεῖν) abstract qualities like small and large in and of themselves (524c).[77] Through thought, then, the soul may arrive at "a vision of the quality of number" (θέαν τῆς τῶν ἀριθμῶν θύσεως) that leads one toward "truth and essence" (ἀλήθειάν τε καὶ οὐσίαν, 525c). Geometry, too, will prepare the soul to see (κατιδεῖν) the Idea of the Good (526e), and in these ways both arithmetic and geometry direct vision to the intelligible realm of the soul rather than the phenomenal realm apprehended by the eye. Yet even in the material world of buildings, statues, and the like, vision may engage with certain objects that take one beyond common visual experience. Plato's characterization of geometry as beautiful (*Timaeus* 53e–54a) or exemplary of absolute beauty (*Philebus* 51c-d) separates its apprehension from common vision even though it is the eye that apprehends geometry.

Among the organs of perception, Plato assigns special status to the eyes.[78] In the *Timaeus*, vision is given by God (47a), and in the *Republic*, the eye is a sumptuous expenditure created by the divine craftsman (507c).[79] Like the sun, the eyes are made "light-bearing" (φωσφόρα) from their possession of a pure fire within that is related to sunlight (*Timaeus* 45b). Like the sun, light radiates from the eye. Having flowed out from the eye, this light's kinship with sunlight allows it to form a body (σῶμα) with the light of day (45c). In this way, vision is related (but not equal) to the divinity of the sun in that light reaches out and connects the viewer to the object seen, and furthermore the sun is the cause of vision (*Republic* 507e–508a). In turn, the sun owes its presence to a higher, transcendent being that is the cause of the sun's own light: the Idea of the Good that illuminates the intelligible realm as the source of truth, knowledge, the right, and the beautiful (508e, 517c).

As an art exemplifying the beautiful, geometry's relationship to seeing may be of great importance for how Plato's concept of *ideai* draws on existing practice and thought. What it means for geometry to be beautiful may be understood through Plato's discussion of beauty by way of the viewer's experience of beautiful bodies. Just as an influx (ἐπίρρυτον) of light from the sun to the eye empowers vision (508b), the lover who sees the beautiful body of a boy "takes in the stream of beauty through his eyes" (δεξάμενος γὰρ τοῦ κάλλους τὴν ἀπορροὴν διὰ τῶν ὀμμάτων, *Phaedrus* 251b). In addition to the emission of light from the eyes, then, there is an inflow as well. Furthermore, beauty itself behaves like light emitted from the eye or sun. Like the sun has its counterpart in the intelligible realm as the Idea of the Good that illuminates truth, beautiful things recall the Idea of Beauty that, unlike other Ideas,[80] shines forth with light that the soul takes in (*Phaedrus* 250b-d). In the form of a boy in the phenomenal realm, beauty emits a stream into the eyes of his lover, recalling the Good's emission of radiance while the lover plays the receiving or even female role.[81] Similarly, in the intelligible realm, the Good plays the role of female, giving birth (τεκοῦσα) to the sun that radiates in the phenomenal realm (*Republic* 517c). The lover of learning, too, plays the female role as the rational part of his soul "draws near and copulates with the really real" (πλησιάσας και μιγεὶς τῷ ὄντι ὄντως) so that, giving birth (γεννήσας) to mind and truth, he attains knowledge (490b).[82] This birthing of mind or intelligence (νοῦς) and truth (ἀλήθεια) is the end of an arduous journey driven by desire, for which beautiful (and therefore penetrating) geometry prepares the philosopher by directing the soul's vision toward the most blessed reality that is crucial for him to see (ἰδεῖν, 526e).

As Heidegger recognizes, birth characterizes making as well, as in his general reading of truth (ἀλήθεια) itself as a bringing forth into "unconcealment" through the work.[83] Similar to the philosopher's engendering of truth, the art of the *tekton* (builder) is, in Greek, *tektein* (to build), which is related to *tiktein* – to give birth.[84] Of course, a carpenter can bring forth a couch or table as an embodiment of the *idea* seen within his own mind. A builder, however, must build the *ideai* of the *architekton*, or master builder. For the builders to see his *ideai*, the architect may provide *paradeigmata* or models, perhaps in the form of drawings produced with the compass and straightedge. On observing these, through mimesis, the builders may bring forth their embodiment as the building.

Both building and truth, then, follow upon viewing a model. Against this background of geometry, birth, and beauty one may explore the possibility that Plato's (and ultimately Heidegger's) poetic understanding of *ideai* could have emerged from existing practices in the art of building. As I discuss later, Plato's similar metaphorical employment of *paradeigmata* may strengthen this possibility. If the potential connection between the respective philosophical and graphic *ideai* of Plato and architecture seems too tenuous to grasp, one may recall that in the fourth century, there simply was no "architecture." To see architectural metaphors at work in that period, then, one must consider a range of references that Plato and his Greek readers would have been unlikely to separate conceptually, including craftsmanship, building (as in *Philebus* 56b-c), and even astronomy and clock making.

GEOMETRY, CRAFTSMANSHIP, AND COSMIC MECHANISM

In response to the unpersuasive case of the Parthenon's reliance on ichnography for an experiential value, up to this point, I have asked whether contemporary architectural theory may have emphasized some other value for *ideai* that may justify their use. As a contemporary treatise on sculpture that itself ostensibly drew influence from lost architectural thought, the lost *Canon* of Polykleitos, the celebrated Argive sculptor of the fifth century, may be relevant. Texts of the Hellenistic and Roman Imperial periods claiming to represent the views of Polykleitos (Philon Mechanikos *On Artillery* 50.6, Galen *On the Doctrines of Hippocrates and Plato* 5.48) appear to suggest that beauty or "the good" as a result that seems to have been desired for Pythagorean motivations depends on a mathematically based commensuration that is then adjusted.[85] According to this later testimony, "the good" features calculations as an important *step* in a process of design focused on the perception of the viewer, considering that the numbers themselves produce "the good" *para mikron*, "except for a little."[86]

Yet it is more difficult to support the notion that the application of a non-sensory, mathematical *idea* separate from optical experience was valued in its own right. Rather, the later testimonies seem merely consistent with the notion of architectural design as a calculation of dimensions based on integral proportions, just as one finds in the repeated 4:9 ratio in the dimensions of the Parthenon. Understood from this reading of the Polykleitan point of view, however, "the good" itself of the Parthenon may have emerged from the adjustments of inclination and curvature (Figure 20), as well as levels (Figure 21), that address the eye of the viewer at a highly refined sculptural level. The value of ichnography as a transcendent notion answering to epistemological rather than practical and experiential considerations in this case remains inconclusive, and the Parthenon's design is perhaps better explained as a result of simple calculations and sophisticated optical refinements. Natural as they appear to us today, then, ichnographies of the Parthenon (Figure 2) may very well be sole products of modern study that would have struck the temple's designers as irrelevant to their purpose of addressing the eye of the viewer.

If this interpretation of Classical architecture's overriding experiential agenda holds, it potentially supports an approach to the question of ancient Greek ichnography from a strictly architectural-archaeological standpoint rather than a method that also considers the concerns of philosophy. Pythagoreans contemplated numbers as a kind of ultimate reality underlying nature. In conjunction with an antisophist agenda,[87] Plato denigrated modifications for perception with respect to the truthfulness of straightness and proportions and the beauty of geometry. Yet regardless of whether architects and sculptors adhered to a Pythagorean mysticism of numbers or anything resembling the idealism of Plato, these visual artists were in the business of addressing perception, not numbers, Ideas, or the anxieties of deception.

Nonetheless, this last assertion raises an additional reflection on the relationship between making and philosophy as Greek activities featuring an *awareness* of differences in approach to number and geometry. In addition to possible connections between Polykleitos' theory and a Pythagorean interest in measure, for Plato, the role of measure in the act of making is of central importance. In addition to his comments cited earlier in the chapter, Plato looks to craftsmanship as a model for cosmology. In creating the world, God is a divine maker (ποιητής) or craftsman (δημιουργός) who establishes the Ideas as measures and imitates them in the phenomenal realm in a way that aims toward exactness in conforming to those measures.[88] Plato's cosmology depends on notions of real making for his account, and in doing so he necessarily brings real making and its strategies into the epistemological concerns of philosophy. Moving in the direction from philosophy to art, Polykleitos and Greek architects may have translated the Pythagorean value of number into a plastic and optical experience, potentially corrupting the purity of number for an artistic expression of beauty and the good.

As Walter Benjamin argues in his classic essay on translation, this element of corruption is a defining feature of the translator's work.[89] In their recalcitrant deferral to intuitive adjustment or optical correction in pursuit of beauty or the good, Polykleitos and Greek architects construe number and straightness as pure and true but, justifiably, subject to distortion in the realm of sensory apprehension. For Plato, beauty in sculpture is contingent on whether the sculptor adheres to true rather than refined proportions (*Sophist* 235d-e), and in doing so he forges the connection between truth and beauty and elevates geometry and the Ideas to the realm of the beautiful. As per Derrida's reflections on translation, furthermore, there exists a covert contractual interdependence between an original and its translation that necessarily remains unacknowledged by each.[90]

In this way, beauty or fineness – a property of visual art and the phenomenal realm – gains epistemological value whereas truth acquires art's character of beauty. Looking back to an older time before sculptors made adjustments to the proportions of their works for the sake of perception (*Sophist* 235e), Plato's project would establish an alethic element in the older approach to sculptures that faithfully imitated the commensurations of their *paradeigmata*. Plato also confers this element on the art of building that, with respect to lesser arts like music, medicine, and agriculture, occupies a privileged position because its tools of trade (compass, straightedge, set square, plumb line, and peg-and-cord) allow for a "scientific" (τεχνιχωτέραν) approach in the precision of measurement (*Philebus* 56b-c).[91]

Plato's recognition of this exactitude in the art of building may therefore call one's attention to the question of what embodies measurement. Unlike the Pythagoreans, for Plato it is not numbers that comprise the essential reality of a human or a sculpture or a building. Rather, numbers comprise both eternal elements transcending phenomenal experience and an important *operation* in the imitation of models in arts like sculpture and building that call our attention to the truth underlying the things we see in our everyday world.[92] In this regard, up to this point, I have underplayed what is perhaps a notable difference between Pythagorean and Platonic thought. Whereas the former appears to have viewed numbers as concrete elements in space, Plato views each number as an individual and transcendent Idea that is separate from phenomena. As immutable individuals, numbers in the ideal realm are not subject to calculation, which takes place rather in the phenomenal realm among countable and commensurable objects.[93] This difference from Pythagorean thought tellingly emerges in the *Republic* where Sokrates criticizes those who use hearing to measure musical intervals, just as astronomers use visual observation as the basis for measuring time (530d–531c). A problem for Plato in both music and astronomy is the direction of the senses toward phenomena rather than application of reason toward "the Beautiful and the Good" (531c). Concurrent with this problem is the measuring of phenomena like astral movements against one another only, and without reference to an Idea as an absolute standard or model. But with respect to Plato's esteem for the metaphorical value of the art of building expressed in the *Philebus*, against what models do the architects with their tools of precision measure their buildings?

Plato may answer this question in a discussion of vision, truth, and models in astronomy and craftsmanship. In an important passage in the *Republic*, the distinction between what astronomers see and measure and the underlying truth of such optical apprehension and calculation is again grasped through metaphor. Accordingly, we are to treat the astral bodies and the quantifiable rates of their velocity in the revolving cosmos as models or *paradeigmata* of the ultimate reality in a way similar to the geometric diagrams of Daidalos or another craftsman or painter (529c-e). This direct reference to the diagrams of the mythical architect Daidalos may carry significant implications for how Plato understands drawing in the art of building.

Yet if Plato here intended to refer to graphic models in Vitruvius' sense of *ideai* (scale drawing and linear perspective), there is nothing in his text to directly confirm this intention. In the most straightforward reading of the passage, it is only clear that the diagrams of Daidalos share a kinship with the revolving motions of celestial bodies. More specifically, Plato argues that one cannot access universal truth through viewing the cosmic bodies, whose movements provide not truth itself, but rather models of truth in the same manner as the diagrams drawn by Daidalos or another craftsman or painter. Plato realizes the full implications of this discussion in the *Timaeus*, where the sight of models in the phenomenal realm leads one toward a higher kind of vision in the transcendent realm.[94]

Plato's reference to the drawings of the mythical architect provide no insight into their character and function, but they do offer the interesting observation that such drawings are somehow appropriate in a discussion of cosmic order. In the *Timaeus*, this connection becomes clearer as Plato gives his account of the divine craftsman's reliance on "eternal models" in his construction of order in the universe. One may well ask what in the experience of Plato and his readers allowed this metaphor of models on the part of a craftsman to work in a discussion of cosmic order. Clearly there may be something about the drawings of a craftsman, like those imagined for Daidalos, that are not antithetical to notions of cosmic mechanism. In other words, it is possible that the distinctions between diagrams for craftsmanship and diagrams of cosmic mechanism were not so great that the former would not be out of place in a philosophical discussion of celestial motion. Viewed metaphorically, a graphic illustration of cosmic mechanism may itself be a model in the same manner as a craftsman's diagram, particularly if a model is to be used in the construction of the cosmic order by a divine craftsman.

Taken along with the philosophical metaphors of craftsmanship, therefore, the *Republic*'s reference to the diagrams of Daidalos serves as a useful induction for further inquiry into the nature and purposes of drawing in the art of building, along with astronomical representation. Among other topics, in Chapter 2 I address what one may understand by diagrams of cosmic mechanism in the Classical period. What might such drawings have looked like? How did they relate to Plato's emphasis on geometry and its importance for beauty and truth?

How would drawings relate to the kind of vision that Plato discusses? Such questions will open a related, though separate, range of considerations that support a new theory for the genesis of ichnography and linear perspective in a context of vision applicable to representations of cosmic order.

SUMMARY AND CONCLUSION: ARCHITECTURAL IDEAS

We may succinctly summarize the implications of this chapter for the question of architectural representation. Vitruvius' use of the Greek term *idea* for architectural models as reduced-scale architectural drawings suggests a possible correspondence with Plato's philosophy in the Classical period. If one may look to Plato for reflections of the details of architectural theory before him, the shared term opens the further possibility that Plato knew of *ideai* as models in the sense of ichnography, orthography, and perspective drawings.

On further examination, however, Plato's discussion of drawings in his reference to Daidalos becomes especially relevant to the question of what kind of drawings his contemporary Greek readers had in mind. Plato's focus in this reference is not to describe the forms or purposes of Daidalos' diagrams, but rather to address the kinship between them and the movements of the cosmos for the sake of discussing the relationship between vision and the ultimate truth. At first, Plato's interest here appears to detract from evidence for scale architectural drawings at work before Plato. Combined with the difficulty in defending the contingency of the Parthenon and other Classical buildings on ichnography, the question of whether the architects of these buildings made use of such drawings must at present remain unanswered.

Yet this question probably also misses the point. The strange connections that one encounters between building, astronomy, and philosophy give rise to additional considerations that may expand our understanding of the ways in which classical architects may have thought about their buildings, the sources that they may have drawn from and influenced, and what the domains of knowledge were that may have comprised what would come to be called *architectura*. Arguably, the day the world changed for the art of building was not the day that a Greek architect drew the first ichnography. More compellingly, it was the day that ichnography first became *architectural*. Whether or not ichnography existed for cases in which its application does not appreciably shape a building is a question of only limited interest to architecture.

For ichnography to become architectural, I mean something more than what may be achieved arithmetically through the integral proportions of a Pythagorean triangle or a 4:9 rectangle. "Architectural" in a Vitruvian context arguably may encompass not just an embodiment of graphic ordering (*taxis*) and positioning (*diathesis*), but also the three parts of architecture: building, chronometry, and mechanisms, all of which are related through geometry.[95] A complete unification of these parts is found in the Pantheon (Figure 1), where geometry frames an envisioning of cosmic motion in time through the Roman application of concrete that brings the traces of the compass and straightedge into monumental presence. Directing our focus toward this integral conception of architecture should not awaken a mystical tone, like the bringing forth of cosmic being. Rather, from a classical perspective, architecture perhaps has more to do with the element that allows for its creation in the built world and the classical observer's recognition of it in the structure and mechanisms of nature.

That element may be understood as something tangible: the planar geometry of the classical architect's compass and straightedge. These simple tools are the means of ordering the *idea* of the building and envisioning the order of the universe. In approaching ichnography as the planar construction of large-scale architectural space, one must first address the simple yet astonishingly sophisticated applications of the compass and straightedge in Greek technical drawing. In the following chapter, I explore the genesis of reduced-scale drawing in the context of vision that, as a faculty expressed etymologically through the term *idea*, came to shape a sense of underlying order in the universe through the tools and methods shared with architects. This exploration will show that if Plato did think of diagrams of cosmic mechanisms in his reference to Daidalos, such drawings themselves may have reflected something else entirely: the existence of linear perspective and ichnography.

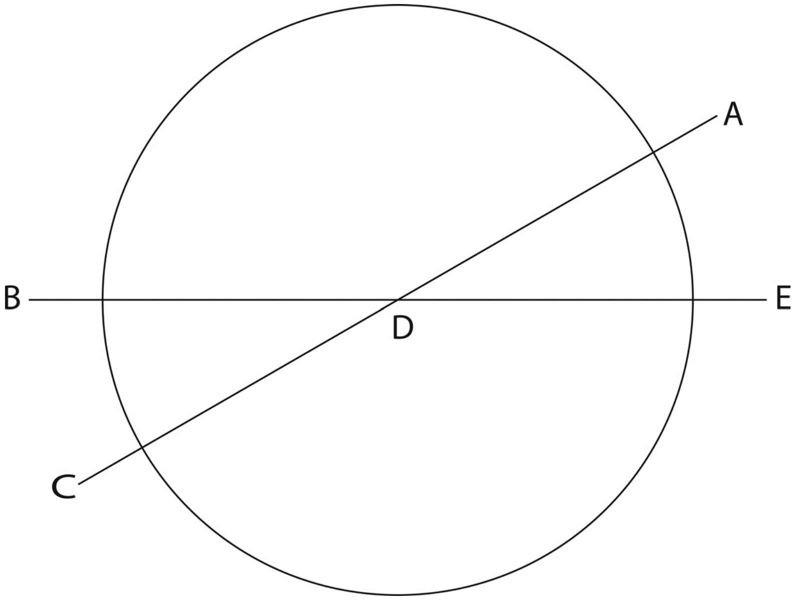
TWO

VISION AND SPATIAL REPRESENTATION

Even with Plato's subsequent elaboration on the relationship between craftsmanship and cosmic mechanism in the *Timaeus*, the *Republic*'s comparison of the diagrams of Daidalos (or another craftsman or painter) and the motions of heavenly bodies may seem strange, perhaps exceedingly so. In looking into the formal and conceptual connections shared by Greek diagrams of cosmic mechanism and the graphic underpinnings of round and partially round Greek buildings, this chapter attempts to demonstrate the naturalness of Plato's comparison in the larger context of classical visual culture. Specifically, I aim to show how in the Classical period, the design of the Greek theater as a circular and radial construction relates to theories of vision, the recent invention of linear perspective, and astronomical drawings representing the revolutions of bodies in space and the passage of time. The revealed connections help locate an early application of ichnography in the design of the theater as a vessel for communal vision. They also demonstrate a nexus of conceptual associations available to Plato when he referred to the diagrams of Daidalos. Finally, they demonstrate that the relationship (or, just as significantly, a simple lack of separation) between building, mechanism, and astronomical timepieces that together define architecture for Vitruvius may be found in notably earlier Greek traditions. This background will serve to more fully inquire into the origins of linear perspective and ichnography in Chapter 3.

Seeing the Universe

In his *On the Revolutions of the Heavenly Spheres*, Copernicus found little to convince him in Euclid's proof of a geocentric universe.[1] Illustrated by a demonstration with the compass and straightedge (Figure 34), Euclid combined visual



34 Diagram for Euclid's proof of a geocentric universe, featuring the location of the viewer on earth at the center of the circle of the horizon (*D*), the rising point of the Crab (*C*) and Lion (*B*) and the setting points of the Goat Horn (*A*) and Water Pourer (*E*). Drawing author.

experience with reason in this first theorem of his *Phenomena* of the late fourth century. Copernicus' problem with the theorem was nothing so fundamental as Lobachevsky's challenging of the underlying assumptions of Euclid's parallel postulate, setting the stage for non-Euclidian geometry in the nineteenth century. Rather, it was confined to just this single theorem's conclusion that the earth occupies the center of the cosmos.

It requires little skill in mathematics or astronomy to immediately grasp what Copernicus faults in Euclid's chain of reasoning. Euclid begins with a *theoros* ("viewer") positioned on the earth's surface and a sighting tube (the dioptra) perhaps fitted with a protractor for measuring angles.[2] After the *theoros* looks through the sighting tube toward the point at which the constellation of the Crab rises in the east, he may reverse his position and gaze westward through the tube, finding the point of the Goat Horn's setting along the same axis of vision. Maintaining this westward view, if he then aims the sighting tube at the setting point of the Water Pourer, he may again reverse his position and find the point of the Lion's rising point along a second shared axis. Euclid represents this experience by drawing the circle of the horizon (Figure 34) along which appear the rising points of the Crab (*C*) and the Lion (*B*) and the setting points of the Goat Horn (*A*) and the Water Pourer (*E*). The two axes corresponding to the direction of the sighting tube converge at *D*, the point at which the viewer stands on the earth. Both *ADC* and *BDE* describe the diameter of the compass-drawn circle. Therefore, according to Euclid, the astronomical diagram proves that the earth is located at the center of the cosmos. Obviously, this proof is fixed by the assumption that each of these constellations is equidistant from earth in the first place. In a remarkable way, then, the circular diagram may appear to demonstrate nothing more than circular reasoning itself.[3]

Contrary to this negative assessment, however, one may also interpret something far more interesting than failed reasoning in Euclid's theorem. In his *Elements*, Euclid shows a remarkable coherence in his theorems that provide proofs for a set of postulates that are embedded with presuppositions. The first theorem of his *Phenomena* is in this sense no different, and here one of the presuppositions handed down to Euclid is that the earth appears within the larger sphere of the cosmos, on the surface of which all stars are fixed.[4] Working from this presupposition, the compass and straightedge do not simply prove an existing account of the structure of the universe. More than this, the drawing theorizes a perspectival experience with its sight lines projecting through space by means of a reduced-scale representation of the universe from an abstract vantage point from which no viewer could otherwise witness. Within the drawing, the earthly vantage point of the *theoros* is itself represented by the center of a circle from which the axial sight lines radiate. In positioning the viewer of the drawing outside of this perspective, he is able to theorize the perspective itself in relation to the revolving cosmos as an ontological, panoptic totality. In this way, the compass and straightedge enable the theorem (θεώρημα) as a speculation to be seen.

Beyond revealing the structure and order of the revolving cosmos, this graphic construction of the viewer's perspective meaningfully relates to another interest of Euclid. In the *Optics*, Euclid theorizes vision according to rays that form the geometry of a cone with its apex at the eye and its circular base at the maximum visible distance.[5] In actuality, the outline of the base would depend on the shape of the object being observed. But to cite Euclid's own example from the *Phenomena*, the concave inner surface of the sphere of the cosmos observed from the earth would form precisely the circular base, just as described in the case of spheres in Propositions 23–27 of the *Optics*.[6] From the perspective of the eye of the viewer on earth, then, the conical view toward the sky would terminate in a theoretical base of the same circular form as the diagram of the sight lines on the revolving cosmos (Figure 34).

Another similarity between this theoretical perspective and the diagram of it emerges when one considers two important passages in Vitruvius, which John White has convincingly connected with Euclid's cone of vision.[7] The first is Vitruvius' passage on the *ideai* (*De architectura* 1.2.2), where following on his introduction of ichnography and elevation drawing, he describes linear perspective or *skenographia* ("scene painting"). Here, his inclusion of the process of *adumbratio*, or "shading," may reflect the connection between an origin in painting and his present context of the kinds of drawing for architecture.[8] In the second passage (7.praef.11), he presents linear perspective as the invention of a painter in Athens of the fifth century named Agatharkhos, who painted the *skene* of the theater and then wrote a commentary on the subject that later informed the accounts of Demokritos and Anaxagoras. In both passages, Vitruvius describes the geometric construction of linear perspective as radial lines projecting from or receding toward *circini centrum*, the center of a circle as the vanishing point.[9] Classical linear perspective as Vitruvius describes it, then, relates to and possibly derives from Euclid's optical theory,[10] but beyond Vitruvius' uncorroborated testimony concerning the painter Agatharkhos one cannot presently confirm whether linear perspective existed before its appearance in surviving Campanian frescos of the first century.[11] In this and the following chapter, I consider evidence related to optics, philosophy, astronomy, painting, and the craft of building in order to offer a new interpretation of the genesis of perspective and ichnography in the Athens in the fifth century. To do so, I will first introduce the confluence of theories of vision, astronomy, and the metaphor of making in describing the revolutions of the cosmos.

THEORIZING VISION

In the history of Greek theories of vision, the ideas underlying Euclid's geometric study of optics were not entirely unprecedented. For Euclid, geometric features like circles, radial lines, angles, and cones produced with the compass and straightedge create highly rationalized, small-scale representations of qualities of vision in free space. As discussed in Chapter 1, Plato describes vision as the emission of rays from the eye that possesses a fire related to that of the sun with which it coalesces (*Timaeus* 45b-c). Having formed a body, the rays or stream of light return to the eye (*Republic* 508b, *Phaedrus* 251b). Plato's metaphors of light transmission and copulation define no shape for this emission and influx. In the prior century, Empedokles may have left an influential precedent for Plato with his account of vision as a physical contact between particles from the eye and from the object (Aristotle *De sensu* 437b23–438a5),[12] as did perhaps Alkmaion of Kroton's sixth century Pythagorean model of a visual current radiating from an eye composed of water and fire.[13]

Far from propounding a purely abstract geometric analysis, Euclid's *Optics* conveys the physiological properties and processes of visual experience expressed by Plato and his predecessors. In Proposition 1, Euclid emphasizes that the interstices between the rays connected to the eye prevent an object's complete visibility at a given moment of viewing. In Proposition 2, he states that a distant object may elude vision when its entirety is set in an interstice between visual rays, and that the clarity of a visible object is proportionate to the number of angles (and therefore rays) that coincide with the viewing of it.

As evidenced by these characteristics, Euclid's rays are not just lines connecting other lines and points according to conventions of geometry. Rather, they are visual conductors in a manner not unlike the rays of light in Plato's account, represented by Euclid with the geometric clarity of the eye as a point at the apex of a cone.[14]

Geometry's role in representing the structure and order of vision resembles its operation in drawings of astronomical phenomena, and the relationship may not be casual. One must consider the shared tools and practices of technical drawing in the sciences, not to mention the fact that – as in the case of Euclid – it is sometimes the same draftsman who applies these approaches to different fields of inquiry like astronomy and optics. A proper understanding of the background of geometry's application in visual theory, along with the formal similarity shared between Vitruvius' construction for linear perspective and Euclid's own construction of the geocentric cosmos (Figure 34), together may call for a further exploration of astronomical representation.

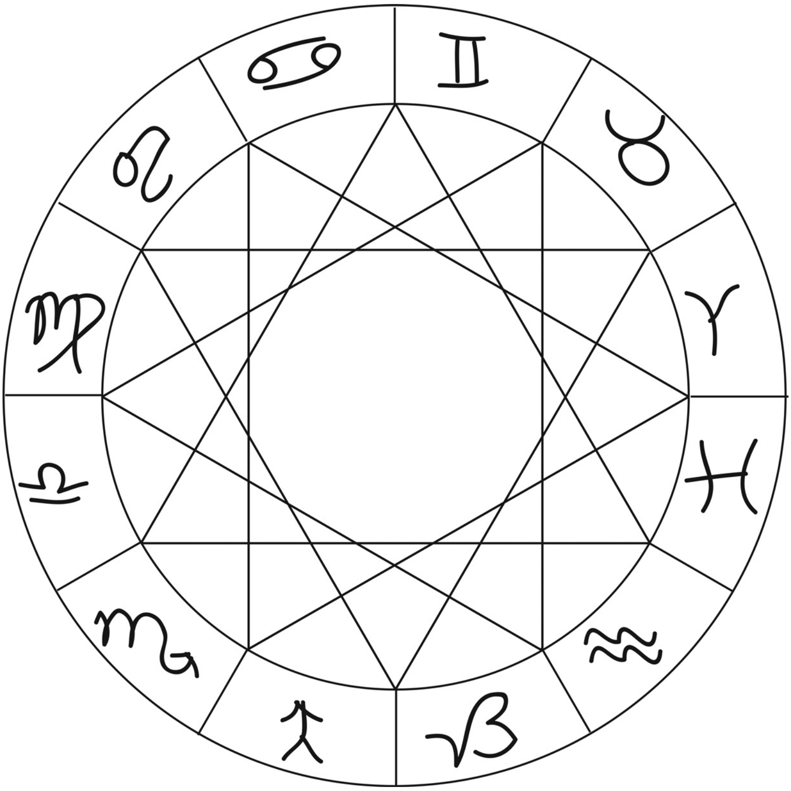
Vitruvius reflects another point of similarity with Euclid, or at least a presupposition that Euclid builds on. Again, Euclid's theorem on the geocentric structure of the universe presupposes a revolving cosmic sphere.[15] The immediate precedent for Euclid's *Phenomena* was the work of Autolykos of Pitane, who wrote his *On the Moving Sphere* and *On Risings and Settings* in the final three decades of the fourth century.[16] In the former work, Autolykos formulates the horizon in Euclid's theorem as a circle dividing the sphere of the cosmos relative to the position of the viewer on the sphere of the earth. What is not relative for Autolykos is the fixed location of the axis of the sphere around which the cosmos revolves, resulting in the eternal circular pattern traced by the stars if one stands with the horizon perpendicular to the axis and their risings and settings when the horizon parallels the axis.[17] In either case, the motions of the stars around the earth may be imitated graphically by the path traced by a pair of compasses, as in Euclid's geocentric diagram. But there is something emphatically three-dimensional in the imagined turning spherical cosmos of Autolykos that anticipates Vitruvius' machine of the cosmos that eternally revolves around its axis, rendering constellations visible or invisible depending on the location of the earthly viewer and the time of the year (*De architectura* 9.1.2–3).

As discussed in the Excursus to this book, the antecedents for Vitruvius' cosmic machine may have been quite old, possibly going back to the revolving machines of Khersiphron and Metagenes, architects of the Artemision at Ephesos in the Archaic period, as well as Anaximander's related model of the revolving cosmos. Like these machines and the timepieces based on the movements of the celestial bodies, the cosmos that Vitruvius' model imitates is, according to Vitruvius, architectural, and is indeed the creation of nature's power as architect. From this Vitruvian perspective, Euclid's graphic demonstration of the revolving cosmos would certainly be architectural. To see the significance of this continuity between astronomy and building for the question of linear perspective and ichnography, one must look at some of the qualities of geometry in representations of the cosmos.

GEOMETRY AND THE COSMOS

One may find this shared quality of making in nature and representation at work as early as Plato. Significantly, the diagrams of Daidalos (or another craftsman or painter) referred to in the *Republic* (529c–530c) serve to underscore Plato's emphasis on the distinction between the "most beautiful" (κάλλιστα) pattern of stars on the surface of the sky and their visible revolutions on the one hand, and on the other hand the truthful rate of intelligible motion underlying the stars. This true velocity can be grasped not through vision, but rather only through reason and contemplation. Plato specifies that both the stars in the sky and the diagrams are creations of a craftsman, foreshadowing the divine craftsman of the *Timaeus* and connecting the stars and the geometry as products of artifice. The same superlative "most beautiful" applies to the diagrams of Daidalos whose spatial measurements, like the temporal measurements of moving stars, do not embody truth. Continuing through Euclid, the spatial measurements of angles and lengths in such drawings (as in the 30 degree angles and equidistant radial lines describing the relevant rising or setting Crab, Goat Horn, Lion, and Water Pourer in relation to the viewer) correspond to the motion of the constellations in time; indeed, Euclid's theorem pertains to not just revolving motion, but also to the necessary synchronic viewing of the constellations in their progress across the sky. For reasons I elaborate through the remainder of this chapter, I propose here that Euclid's geocentric diagram preserves for us a later example of the kind of geometric drawing that Plato knew and possibly reflected on in his passage on the diagrams of Daidalos. Along with astronomy, such drawings reflect a kind of craftsmanship akin to what Vitruvius would later designate as architecture.

With respect to the question of their embodiment of truth, other comments in the *Republic* about geometry and later details in the *Timaeus* elevate Plato's seemingly lower regard for geometric diagrams. Even though geometry may not in itself complete one's journey toward absolute truth, geometry and astronomy both turn the soul's gaze upward to a higher realm (*Republic* 527b, 529b) where one may be better able to apprehend the Idea of the Good (*Republic* 526e). The power of geometry is not in its practical capacity (*Republic* 527a-b), as in measuring real space, but rather in its character as pure "knowledge of eternal being." What Plato upholds is a kind of eternal geometry akin to what, in the *Timaeus*, he would term the eternal model according to which the divine craftsman builds the cosmos (*Timaeus* 48e–49a). Similarly, it is the eternal rather than the generated model that the philosopher should pursue in astronomy

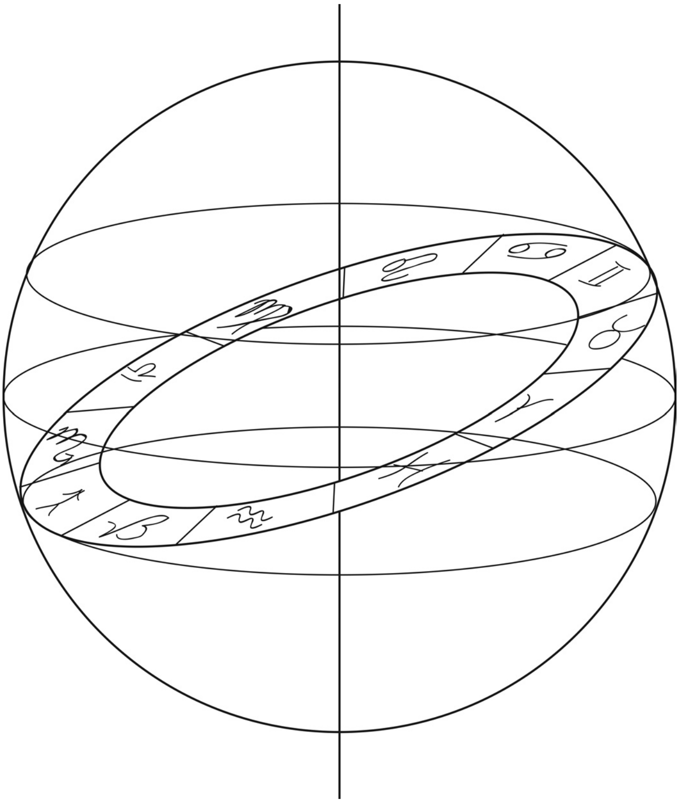


35 The zodiac as a circular construction with twelve equal sectors for the signs. Drawing author.

(*Republic* 529c-d). Plato may find a cosmic diagram or the astral bodies themselves to be "most beautiful," but it is the role of these images in turning the soul's vision toward that Idea of the Good that captures the real value of such viewing in the phenomenal realm.

In this binary of drawings and the actual mechanisms of bodies that they represent, there is good reason to posit that it was the former that were more influential on Plato's account. In the *Timaeus*, Plato emphasizes that, in the divine craftsman's cosmos, the orderly motions of bodies are both akin to the motions within our own mind and self-propelled by divine reason (νοῦς).[18] In our seeing and theorizing the circular paths of these celestial motions, our kindred reason assimilates the quality of divine order that they embody, elevating our own souls so that we may perceive intelligible reality. Plato gives special importance to the relationship between geometry and reason, but his connection between circular geometry and astronomy is not readily apparent in observation without the aid of astronomers and their diagrams.[19]

Specifically, it is to the theories of the contemporary astronomer and mathematician Eudoxos of Knidos that one may attribute Plato's emphasis on the



36 The revolving cosmos according to the model of Eudoxos. Drawing author.

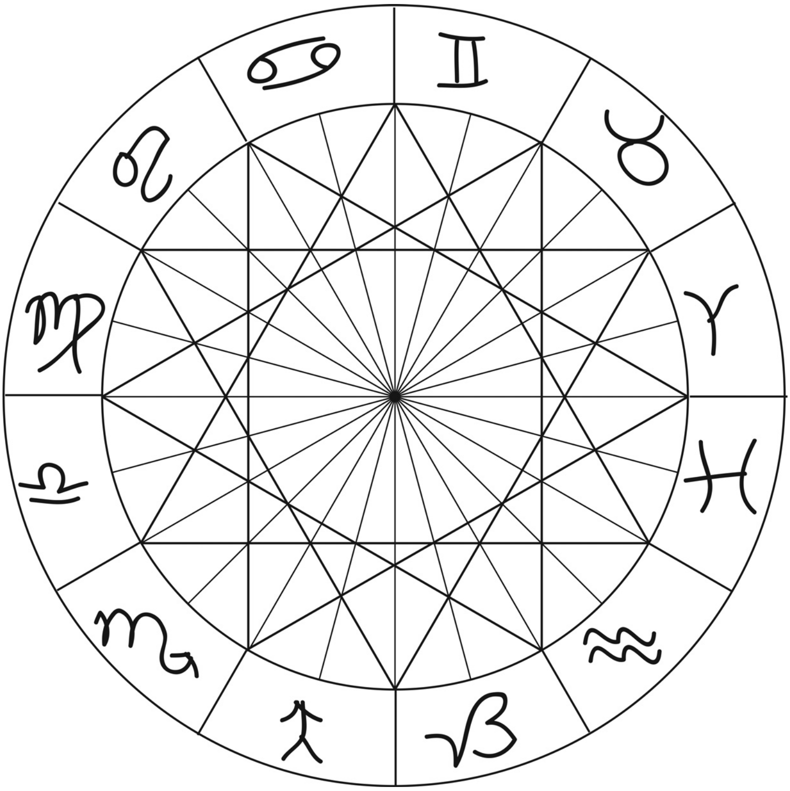
circle.[20] In the lost but nonetheless well-known writings of Eudoxos, the circle described the motions of both the stars and the planets.[21] His zodiac (Figure 35), whose equal sectors treated the constellations as though they were signs of uniform 30° length rather than distinguishing between signs as parts of an equal division of twelve sectors (δωδεκατημόρια) and the varying width of constellations in the later manner, caused errors that Hipparkhos criticized two centuries later.[22] In Euclid's drawing (Figure 34), these equal sectors where the visual axes intersect at the *theoros* underscore earth's central location due to an equal six sectors above and below the opposite rising and setting pairs (Crab – Goat Horn, Water Pourer – Lion). In addition to the zodiac, for Eudoxos three other principal circles describe the equator and northern and southern tropics. Together with the slanting belt of signs, these circles compose the sphere of the cosmos as a geometric construction brought forth through technical drawing with a pair of compasses (Figure 36). In this scheme, a feature of Eudoxos' zodiac that would not enter the canon are what may be understood as bisections of the signs/constellations, as indicated by his intersection of the northern and southern tropics with the middle rather than the beginning of the constellations (Figure 36).[23] This recognition of the centers and not just the borders of constellations may suggest a twenty-four-part rather than twelve-part division of the zodiac (Figure 37).

From the perspective of visual studies, one may reconsider what has been framed as a philosophical rather than scientific basis for the circular nature of the Greek cosmos. Eudoxos is the earliest astronomer known to have explained cosmic motions according to the mathematical properties of circles, and from Plato to Ptolemy in the second century A.D. and beyond, the circular and spherical model of celestial movement remains doctrine in both philosophy and science. More likely than just patient observation of the night sky, for Plato this geometry informs the image or "generated model" that graphically reveals the circular order of the revolving universe to be imitated by the soul of the philosopher. According to a teleological view of scientific development, this philosophical model inhibited a more modern astronomical understanding. An opposing scholarly view both argues in favor of the merits of the circular/spherical model as an aid to development and, more important to our aesthetic concerns here, for the naturalness of the circle in astronomical representation as entirely consistent with perceived appearance: "The stars *are* seen to move in circular orbits across the sky, the sun *does* appear to go round the earth in a circle. . . . "[24] Yet if it is simply natural to see circles at work in the sky, one may well ask why it was the Greeks, and the Greeks only, who came up with this detailed circular model. Given the seriousness and greater antiquity of the Babylonian tradition, why did Babylonian astronomers content themselves with a system of arithmetic progressions?[25] Rather than being natural to universal practices of seeing, one should consider how cultural production itself determines vision and, in a mutually reinforcing way, the graphic models that represent what one sees.[26] If Plato and Eudoxos forged a particular geometric vision of the universe to be shared in philosophy and science, was there something in their shared cultural background that enabled this vision?

As I explore in this and the subsequent chapter, the geometric understanding of the cosmos in astronomy and Plato's emphasis on craftsmanship – divine or otherwise – may be connected in a significant and spectacular way. We have already seen that centuries later, Vitruvius would define cosmic craftsmanship in terms of the Late Republican entity of *architectura*. In seeking the possible inspiration behind the geometry of the demiurgic construction of the cosmos and its eternal model, I will now look to the buildings that may have reflected the compass and straightedge-based creations of the architects who designed them.

GEOMETRIC UNDERPINNINGS OF ICHNOGRAPHY AND ASTRONOMY

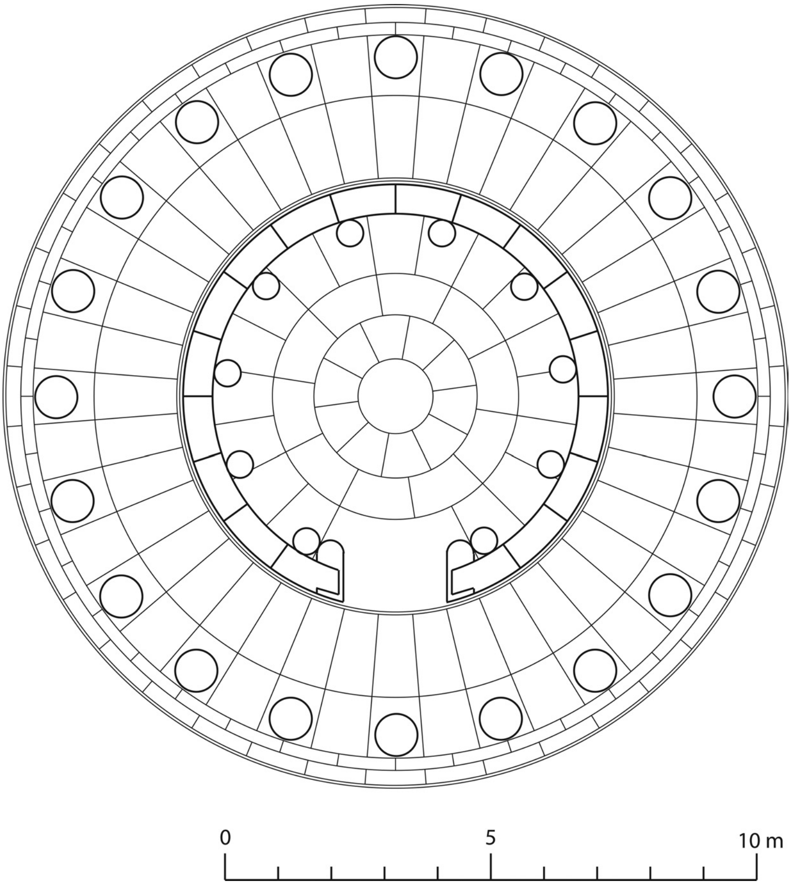
The topic of geometry looms large in the question of ancient Greek ichnography. In clarifying what is meant by geometry in classical architecture, one may



37 The zodiac as a twenty-four-part construction. Drawing author.

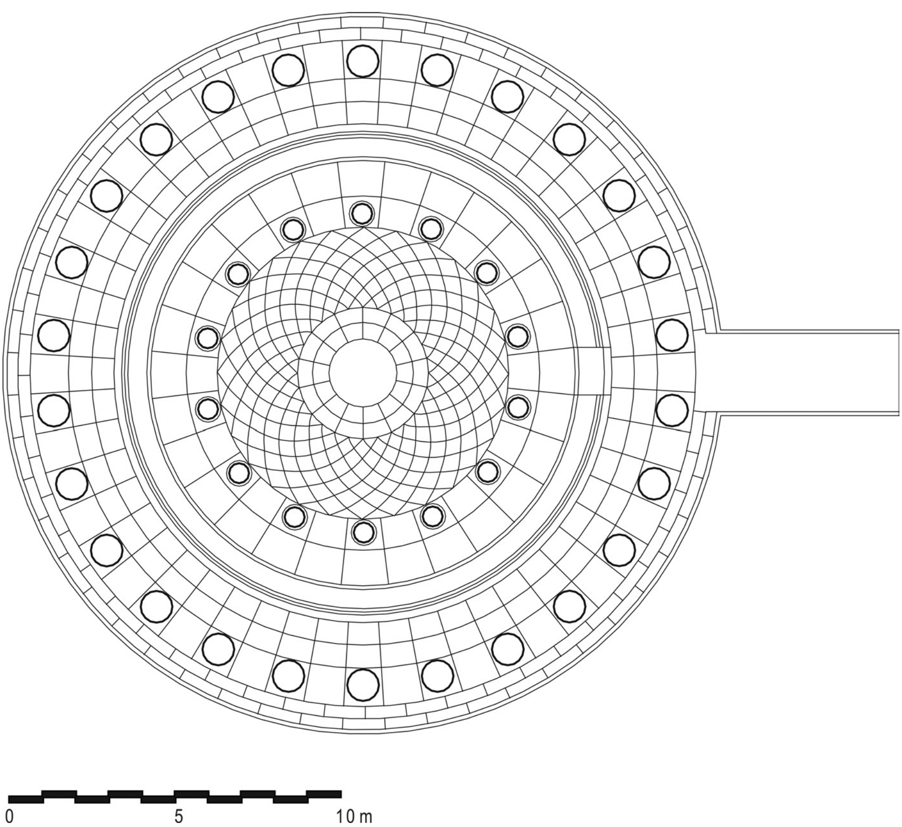
distinguish between the simple orthogonal relationships found in rectilinear temples like the Parthenon or the Artemision at Magnesia (Figure 23), and the nonorthogonal forms like triangles, circles, and arcs underlying Temple A at Kos (Figure 31) or other buildings explored below. Yet another category altogether may be the designs based on irrational geometric relationships like $1{:}\sqrt{2}$ or $1{:}\sqrt{3}$. Although argued to have been part of the design process of Hermogenes, the proposed geometry does not bear rigorous mathematical analysis.[27] Instead, this approach to design may be confined to the Imperial era.[28] The present chapter therefore focuses on principles of the compass and straightedge and related archetypal geometric forms rather than irrational geometric relationships.

Although we lack explicit testimony about the process of their designs, starting in the fourth century one finds buildings whose conceptions are difficult to imagine without the art of ichnography. Contemporary with Plato and Eudoxos in the early fourth century is the Tholos on the Marmaria terrace in the sanctuary of Athena Pronaia at Delphi (Figure 38).[29] According to Vitruvius (7.praef.12), Theodoros of Phokaia wrote a volume on this building, so he was likely its architect. According to a recent metrological analysis, there are significant correspondences with the modular system at work within the Parthenon,



38 Tholos on the Marmaria terrace, Sanctuary of Athena Pronaia, Delphi. Early fourth century B.C. Restored ground plan. Drawing author, modified after Ito 2004: Figure 4–2.

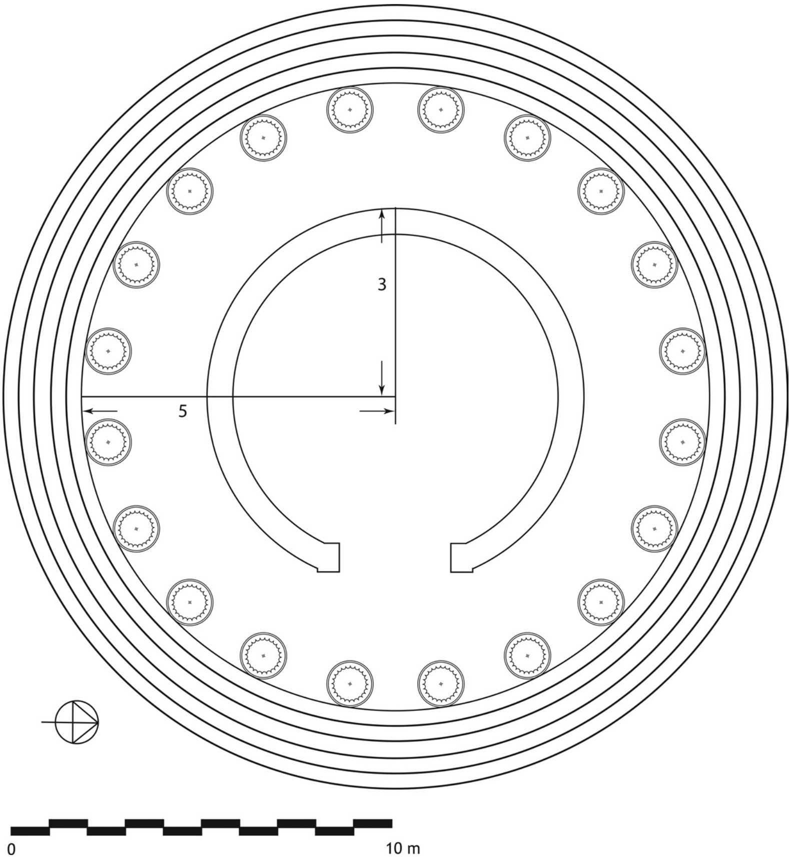
"almost making one think that the Tholos might have been originally planned as a reduced copy of the Parthenon."[30] Whereas this argument rests on comparisons of modular dimensions depending on several loose conversions from metric values,[31] the larger picture that emerges intriguingly suggests at least a possible influential role of coming from Athens. Of course, a fundamental difference from the Parthenon is the geometry of concentric circles in the plan of the Tholos. In this quality, it appears to reflect practices of technical drawing with a pair of compasses. In addition, there is an arithmetical underpinning that, perhaps based on his reading of Theodoros of Phokaia, Vitruvius recommends for peripteral tholoi: an integral 3:5 ratio between the diameters of the cella and the stylobate (*De architectura* 4.8.2).[32] Whatever the relationship to Vitruvius centuries later, the building at Delphi was part of the world of round Greek buildings of the fourth century that finds its richest and most complex expression in the Tholos in the Asklepieion at Epidauros begun in ca. 360 (Figure 39).[33]



39 Tholos at the Asklepieion, Epidauros. Begun ca. 360 B.C. Restored ground plan. Drawing author, modified from P. Cavvadias, in Cavvadias 1891: Plate 4.

Relative to the building at Epidauros, the simplicity of the Tholos at Delphi has a legacy in Late Republican Rome. Beside the Tiber stands the famous Round Temple built of Pentelic marble (Figure 40), likely to be identified with the Temple of Hercules Olivarius of ca. 100.[34] Despite its location, this temple is sufficiently Hellenistic in its ornament and planning to merit attribution to a Greek architect.[35] Its metrology reveals an interesting feature of its plan: the precise whole number ratio of 3:5 circumferences established by the exterior of the cella wall and the stylobate,[36] calling to mind Vitruvius' recommendation for the relationship of these features in peripteral tholoi.

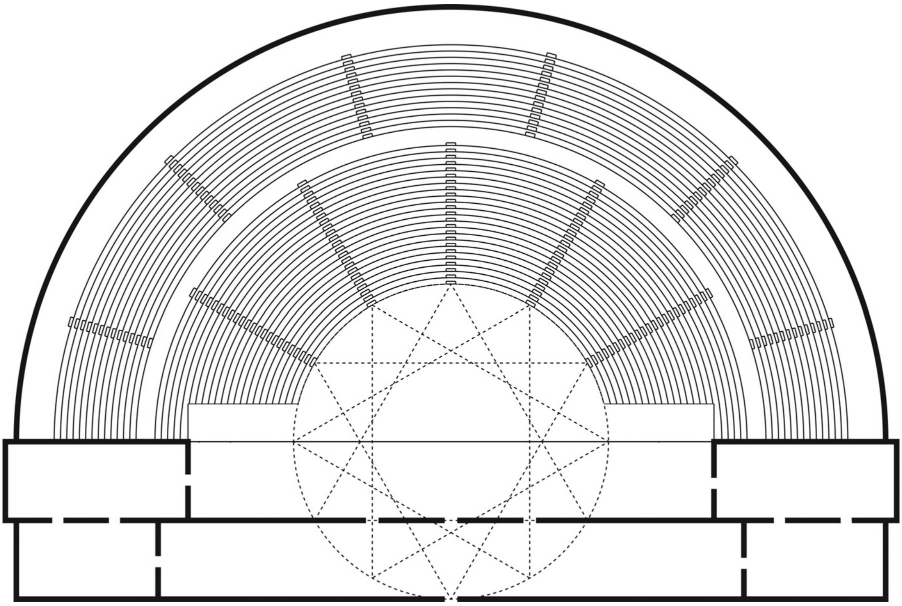
Arguably, however, Vitruvius' confirmation that such a ratio was intentional is of no help to a viewpoint that would wish to see the Tiberside Round Temple or its ancestor at Delphi as evidence for ichnography. At best, Vitruvius articulates an arithmetical relationship between the edges of curved masonry in a straightforward way that would seem to obviate the need for geometric drawing in planning the final built form.[37] In other words, *syngraphai* as spoken or written specifications could express such forms in terms of simple ratios.[38] The observation that forms correspond to commonly repeated ratios in



40 Round Temple, Rome. Ca. 100 B.C. Restored ground plan. Drawing author, modified from Rakob and Heilmeyer 1973: Plate 1.

rectilinear temples (Figures 15–18) should apply equally to what one finds here in the ground plans of tholoi: Namely, that such formulas are readily at hand without need for proportional relationships to be discovered through reduced scale drawing with the compass and straightedge.[39] There are two additional considerations that do not support this view, however.

First, as I detail in Chapter 4, Temple A at Kos of ca. 170 shows this same 3:5 ratio of diameters at work in its geometric underpinning centered on a Pythagorean triangle (Figure 31). It is the circumferential intersections with the compass and straightedge that enable accurate orthogonality in the drawing of straight lines that establish the locations of the euthynteria, cella, and pronaos (Figure 32). Regarding the question of ichnography at Delphi and Rome in the early fourth and late second centuries, this example of course proves nothing. Yet what it does suggest is that the 3:5 formula for circles may have related to the practice of drawing, and not just abstract formulas. In the case of Temple A, after all, it is the process of drawing that establishes the locations of the temple's most



41 The Latin Theater as described by Vitruvius (*De arch.* 5.6.1–4). Drawing author.

important elements in plan in a way that cannot be readily envisioned without a graphic construction.

Secondly, and more significantly, the buildings at Delphi and Rome (as well as other classical round buildings) show a feature not associated with Temple A. In addition to the quality of concentric circles, the surrounding ring of columns and their supporting paving slabs display a radial arrangement. More than just central planning, it is this quality of radiating out from a center that betrays an origin in the application of the compass and straightedge. As one sees in Euclid's diagram of the revolving, geocentric cosmos (Figure 34), the circle with its centrifugal/centripetal lines emerges from the tools of technical drawing. For the moment, this generalization stands as a mundane observation of typological commonalities. An analysis of literary evidence below in conjunction with these qualities of drawing reveals something more fascinating at work, however.

In addition to small, peripteral round buildings like temples and heroa, Vitruvius describes the circular design of the potentially colossal Latin theater (*De architectura* 5.6.1–4).[40] The design begins with a circumscribed set of four triangles with equal sides (Figure 41). This geometry determines the placements of architectural features like the *scenae frons* and the radiating aisles of the *cavea*. By the age of Augustus, then, we find a description – indeed a prescription – of ichnography at work with the compass and straightedge.[41]

In elaborating on the geometric underpinning of the design, the text explains that it is the same as that with "which the astrologers reckon the twelve celestial signs from the musical harmony of the stars," *quibus etiam in duodecim signorum* *caelestium astrologia ex musica convientia astorum ratiocinatur* (5.6.1).[42] Fensterbusch's edition of Vitruvius omits this portion of the text, identifying it as a later insertion.[43] Indeed, the phrase lacks Book 9's more mechanistic emphasis on the zodiac as a belt of twelve signs of equal length rotating at a slant around the earth (9.1.3–5) in way that more recalls Eudoxos (Figure 41). Still, if this comment truly does belong to an interpolator, it could hardly be more appropriate.

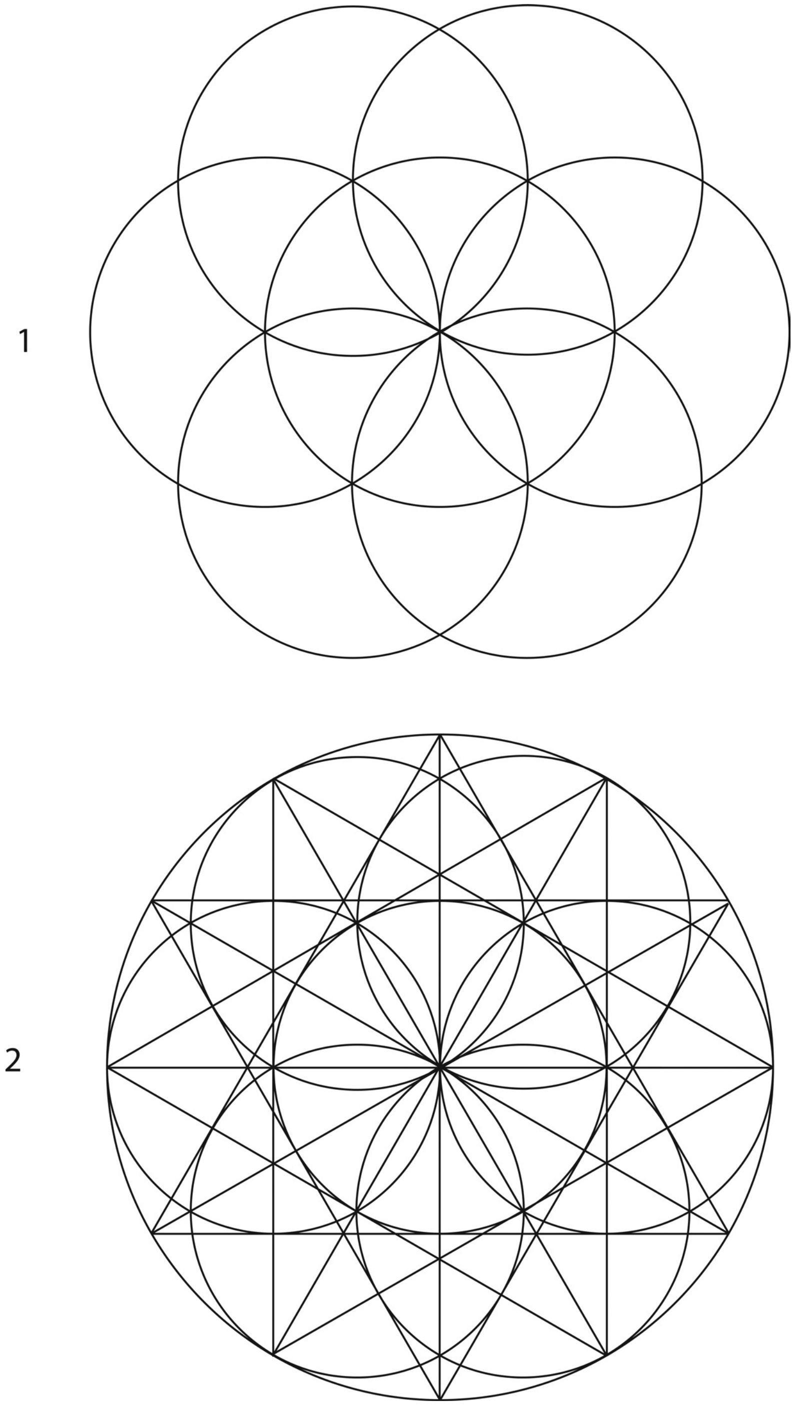
In order to appreciate the significance of this well-founded comparison between the shared geometry underlying Vitruvius' Latin theater and the diagram of the twelve celestial signs (Figure 35), an analysis of the procedure with the compass and straightedge that engenders the form may be helpful. In his account of the education required to prepare one for architectural practice, Vitruvius includes training in drafting and geometry in order to envision the proposed building and, through the compass and straightedge and related tools on site, to execute his vision in real space (1.1.4). Nowhere does Vitruvius explain the specifics of how to work with such tools, which is natural in a treatise that theorizes architecture but is obviously not intended to provide practical training in the hands-on skills that a professional would need to acquire.[44] The way that an ancient draftsperson would go about drawing something like the circumscribed set of four equilateral triangles that Vitruvius described must therefore be reasoned through on the basis of scant archaeological evidence.

Among the drawings that Haselberger observed on the walls of Didymaion's adyton is the repeated form a six-petal rosette (Figure 42.1).[45] Undoubtedly, it is among the oldest and most elementary of all constructions produced with a pair of compasses, consisting of nothing more than seven total circles of equal radius.[46] The graphic algorithm begins on a theoretical shared baseline with two lateral circles centered on the outer arc of a central circle, followed by four more circles centered on the circumferential intersections. The most obvious value of this drawing is that it checks the accuracy of the compass, considering that an instrument with an imperceptibly bent arm will reveal its deficiency with an imperfect rosette.[47] This drawing, therefore, is basic to ancient technical drafting, and no draftsman working in the art of building should have been unfamiliar with the procedure any more than a lyrist would have been unable to tune his own strings.[48]

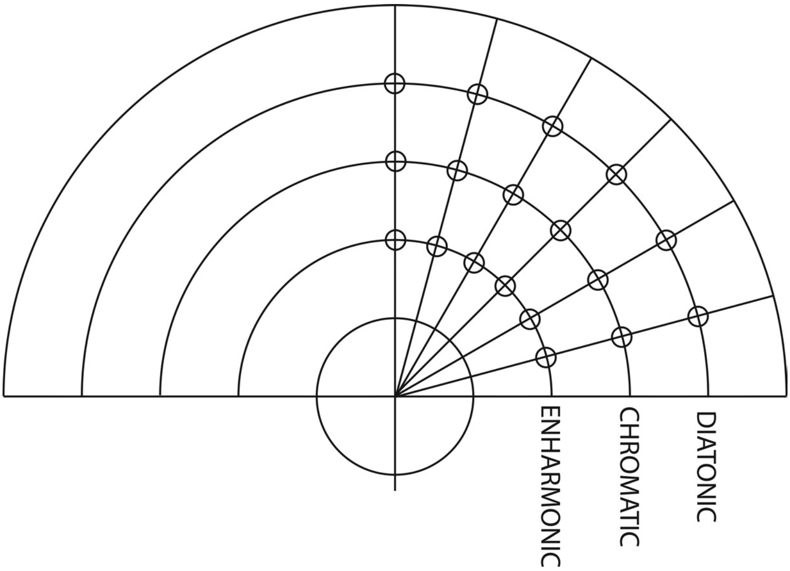
When one considers the operation of the compass in ancient drawing, its relationship to polygons like the equilateral triangles of Vitruvius becomes obvious. As discussed earlier in the case of the ichnography of Temple A at Kos, circumferential intersections produce true orthogonality as well as accurate angles, as in the walls and euthynteria of Temple and the Pythagorean triangle that underpins it (Figure 32). One advantage of a pair of compasses in this regard is that, as opposed to a T-square, the drawing can be executed on any surface, even a wall or a flat stone with a nonorthogonal outline. Furthermore, the habits of drawing would have developed complex ways of working with the compass and straightedge that may seem sophisticated to us, but were natural to those who worked with these tools on a daily basis. There is nothing complex about the circumscribed triangles that Vitruvius describes, however. Rather, the geometric underpinning of the Latin theater (Figure 41) is nothing more than the simple six-petal rosette with the application of a straightedge to connect its circumferential intersections with radial lines and chords (Figure 42.2).

The simplicity and adaptability of this design deserves emphasis. The ease with which the algorithm lends itself to a well-balanced, radial form, I would suggest, may have influenced its adoption for the theory behind designing theaters in Late Republican Italy in the first place, whether or not this theory originated with Vitruvius himself. The appropriateness of Vitruvius or the later interpolator in associating it with the diagram of the twelve signs arises from a familiarity with its geometry at the level of its design process with the compass and straightedge; the identical process establishes the twelve equal sides of 30 degrees for the zodiac (Figure 35). As any ancient person with the slightest familiarity with drafting would have readily grasped, furthermore, the additional intersections of chords would have established the locations of the radiating lines of the aisles in the upper wedges of the Latin theater, thereby staggering them with respect to the aisles of the lower wedges, just as Vitruvius prescribes (5.6.2). The result, then, is a twenty-four-part construction with angular divisions of 15 degrees. It is therefore adaptable to the diagram of the fourth-century philosopher and musicologist Aristoxenos whom Vitruvius refers to, based on the locations of the bronze sounding vessels to be placed in two or four curved rows along the six equal radial divisions of a quarter circle (and therefore 15 degrees) in accordance with harmonic principles (Figure 43).[49] Aristoxenos, in fact, may have been just as likely to employ the same six-petal rosette in the construction of his diagram. Finally, one may even posit that the importance of the centers of the signs in Eudoxos' zodiac as the points of intersection with the northern and southern tropics (Figures 36, 37) may have similarly found graphic expression in an equal twenty-four-part construction.

The resemblances between the Latin theater and the zodiac resulting from a shared geometric underpinning observed by Vitruvius or his interpolator are relevant to both building and cosmic representation. When understood according to a geocentric model, the circle of the twelve signs of the zodiac revolves from east to west. In the opposite direction, the moon, sun, and planets revolve in a circular motion through the twelve signs. With respect to the belt of signs, as Vitruvius envisions, these bodies "roam on a circuit of a different size as though they rotated at different points along an ascending stairway from west to east in the universe," *ut per graduum ascensionem percurrentes alius alia circuitionis magnitudine ab occidenti ad orientem in mundo pervagantur* (9.1.5). The implicit metaphor of the theater that allows Vitruvius and his readers to envision



42 The six-petal rosette: rosette (top) and with circumferential intersections connected with straightedge (bottom). Drawing author.

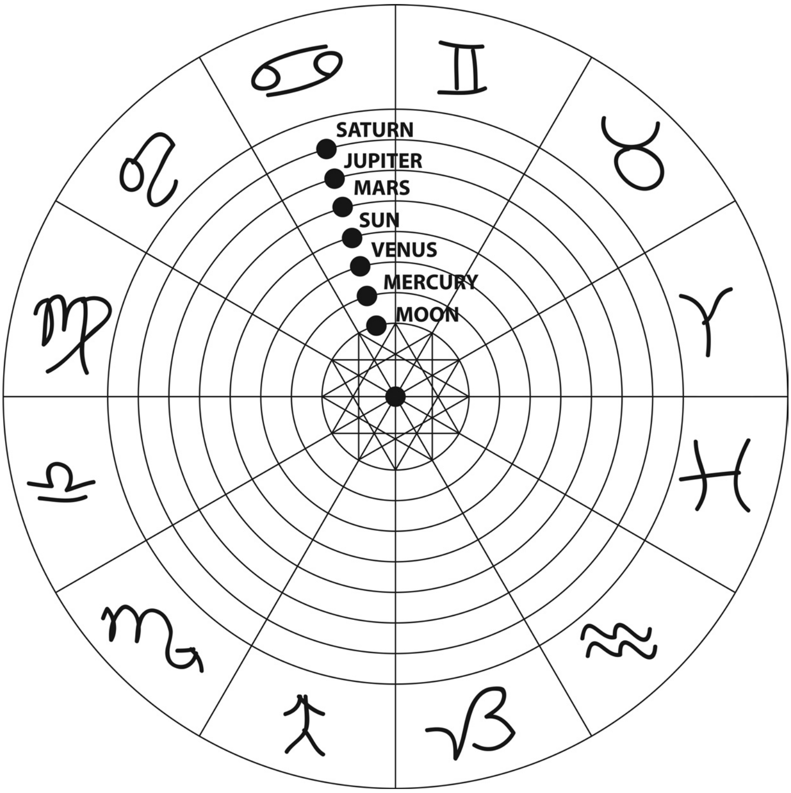


43 Diagram of Aristoxenos (fourth century B.C.) for the placements of sounding vessels in the theater, according to Vitruvius (*De arch*. 5.6.2–6). Drawing author.

the turning mechanism of the cosmos could not be clearer. From the earth at a central position akin to that of the orchestra, the imagined perspective embraces a concentric construction in which the *cavea* and its multiple stairways is the planetary circuit. In turn, this circuit relates to the circuit of zodiac through the perspective of the earthly viewer who locates the progress of planetary movements radially according to lengths of 30 degrees (Figure 44).

One cannot know whether this "theatrical" representation of the cosmos is of Vitruvius' own making or if it reflects an earlier source. Whatever the case, the correspondences observed so far raise the question of whether, for our purposes, there may be an accessible reason behind the adoption of the same geometric underpinning for both the construction of the theater and the representation of space. One may also ask whether theaters and peripteral tholoi from the fourth century onward may be related as products of ichnography. Finally, one may question which of these took the lead in the transition from a sculptural focus to an aesthetic grounded in constructions of space organized according to the concentric and radial principles emerging from the compass and straightedge.

As I argue next, it was the theater as the architect's unique invention of a vessel for communal vision in the city that first brought forth a shape for the notion of order in space in the built world of the city, the sanctuary, and cosmos. Central to this exploration is the mutually enforcing function of models in the perception of the world, as in the way that the theater may work as a model for seeing the universe, and how seeing itself becomes a model for the theater (and vice versa in both of these cases). Yet the most fascinating question

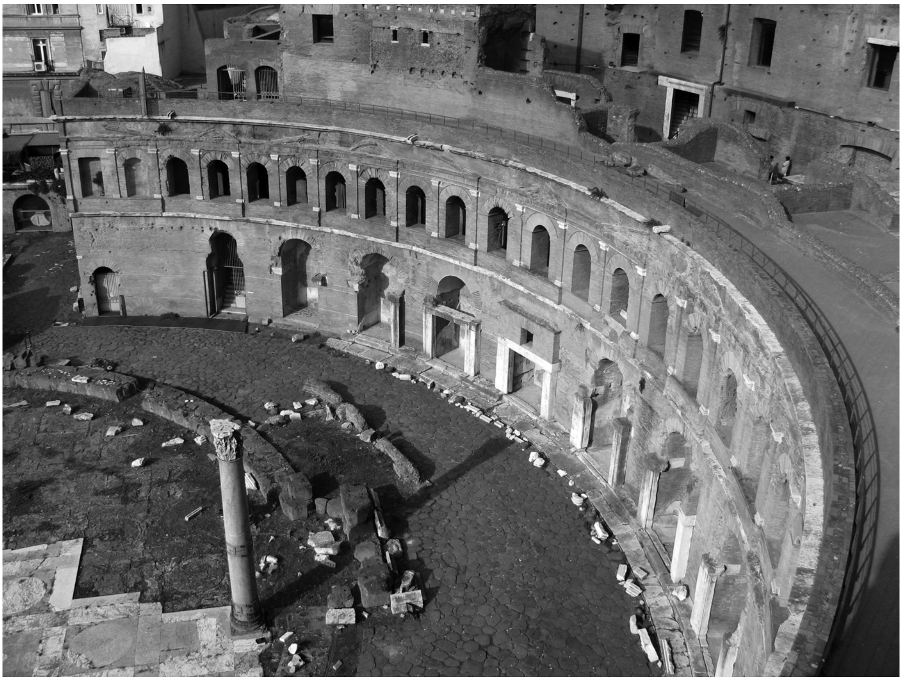


44 Circuits of the revolutions of the moon, sun, and planets through the zodiac, described by Vitruvius as an ascending stairway (*De arch*. 9.1.5). Drawing author.

concerns the originating model that may have made each of these secondary models possible, which is a subject that I take up in Chapter 3. An interpretive analysis of the relevant evidence may suggest that this originating model may have been a process in the art of building itself.

THE THEATER AND THE CITY

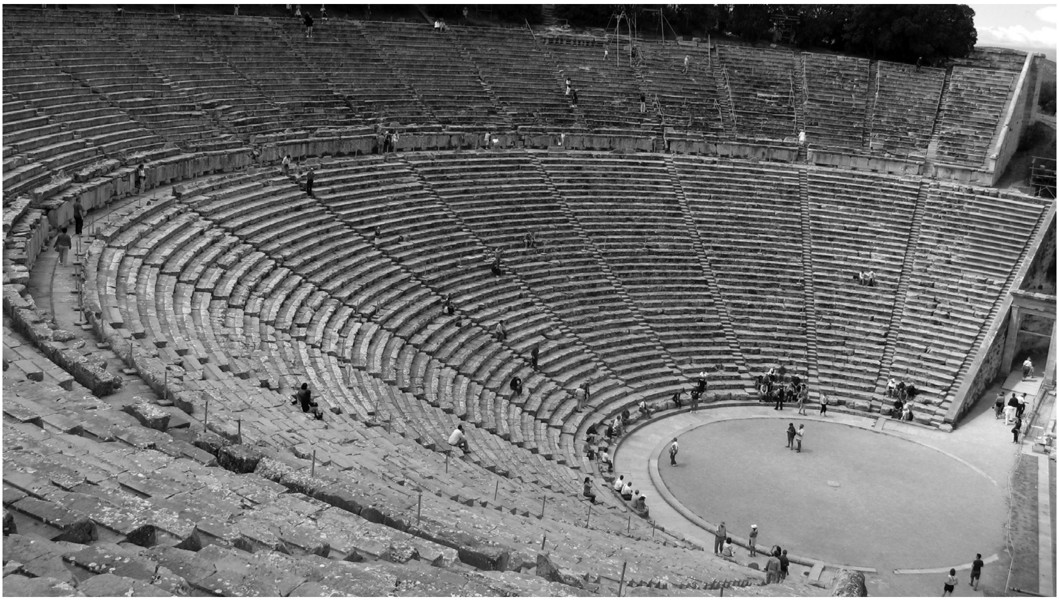
Dedicated in the 50s in Rome's southern Campus Martius, the Theater of Pompey exemplifies the potential of a theater to transform part of a city.[50] As opposed to the Greek tradition of building the seating arrangement on a natural hillside, Pompey's theater was a multistory arrangement, the experience of which is best approximated through later surviving examples like the Augustan Theater of Marcellus in the Circus Flaminius. Pompey's monument went against Republican traditions in becoming the first permanent theater of concrete and stone masonry in Rome, rather than a temporary wooden structure for the purpose of specific spectacles. The excuse for this violation of tradition was that the *cavea* was simply the steps leading up to Pompey's Temple of Venus Victrix,[51] located



45 Markets of Trajan, Rome. Early second century A.D. View from the Via Biberatica. Photo author.

on an approximately 25 m-wide platform on the central axis at the apex of the seating arrangement some 45 m above the surrounding plane of the Campus Martius. Although no longer a visible monument,[52] the imprint of Pompey's theater is preserved in the sweeping curve of the Palazzo Pio Righetti that incorporates the ancient remains into its foundations, still reflecting the trace of the ancient architect's pair of compasses on his drawing board in the manner that Vitruvius describes.

Beyond physically transforming the southern Campus Martius, the form of Pompey's monument set a local precedent for the monumental curvature of Rome's urban monuments from the hemicycles of the Forum Augustum to the Markets of Trajan (Figure 45) and beyond. As in the Imperial Fora, the practice of reduced-scale drawing effectively unified disparate parts into complexes, and even complexes of complexes. The radial arrangement of the aisles of the *cavea* converged on the orchestra, uniting along a single axis extending from the Temple of Venus Victrix to Pompey's *curia* at the opposite extreme of the *porticus post scaenam*.[53] Due to the monumental *scenae frons* placed between the theater and ca. 135 by 180 m gardened space framed by the *porticus* stretching between the area now framed by the Campo dei Fiori and Largo Argentina, neither the temple nor the *curia* was likely to be visible from the other.[54] Rather, the three-dimensional forms placed at differing levels were designed according

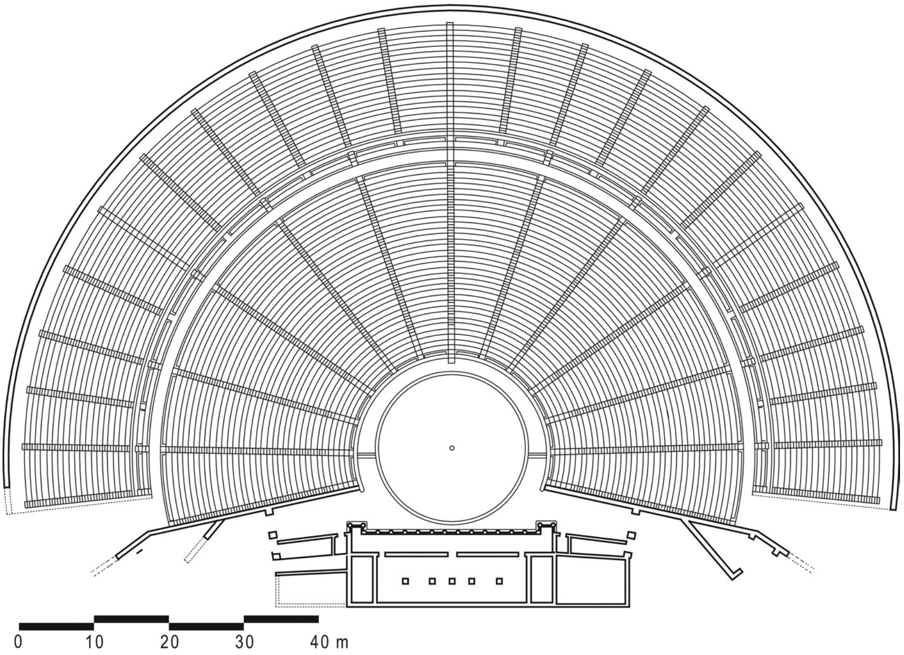


46 Theater, Asklepieion, Epidauros. Begun ca. 300 B.C. View from the upper eastern *koilon*. Photo author.

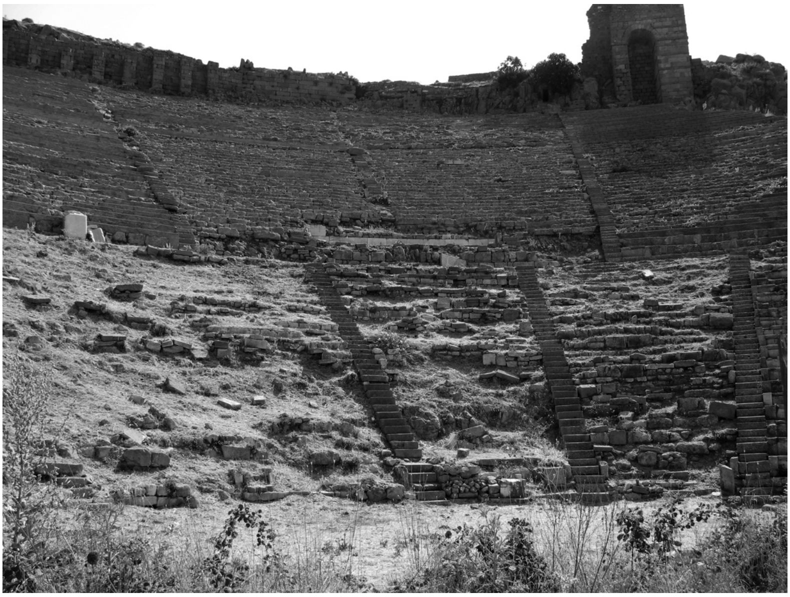
to a planar conception. In this way, ichnography shaped the space of southern Campus Martius and set a precedent for the transformation of Rome into an urban aesthetic largely reflective of the design principles emerging from the compass and straightedge. As much as the introduction of Greek architects, building materials, and models of architectural patronage, this approach to design, so concisely given by Vitruvius in his description of the Latin theater, was central to the Hellenization of the art of building in Middle and Late Republican Rome.

The Greek tradition that Pompey's architect drew on is perhaps most impressively represented by the well-preserved theater at the Asklepieion at Epidauros dating from ca. 300 (Figures 46, 47).[55] If one follows Pausanias' account (2.27.5), the connection between the concentric, radial designs of the theater and the nearby tholos (Figure 39) may be more than casual. According to him, an architect by the name of Polykleitos was responsible for both buildings – a suggestion made problematic by both the possibility that Pausanias may have errantly intended the famous sculptor of the fifth century, and that the start of the tholos's construction likely precedes the theater by some six decades.[56]

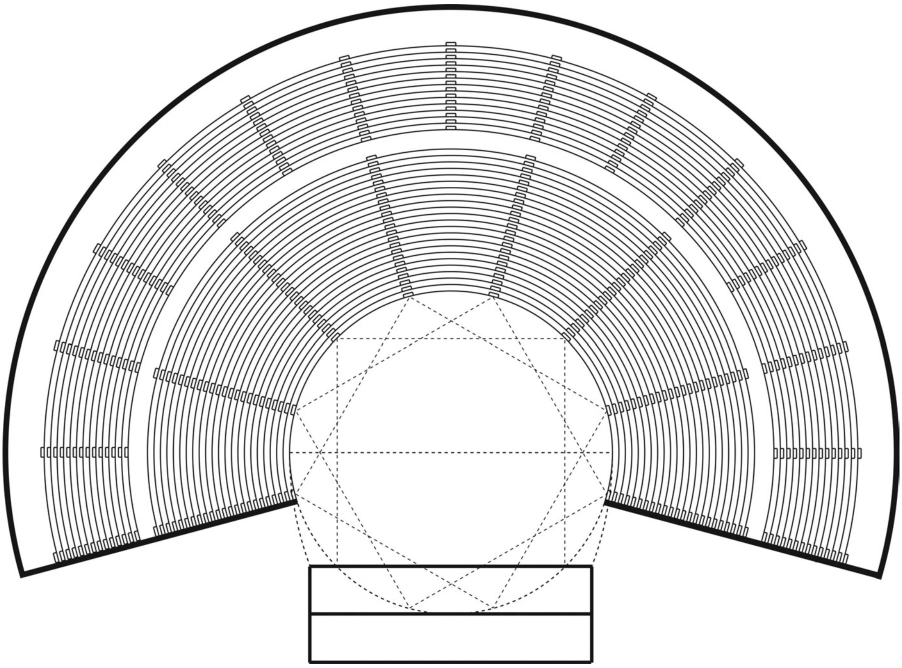
Regardless of these questions of authorship, the monuments at Epidauros herald new approaches to shaping space in sanctuaries and urban environments in the fourth century. The high point of this tendency may be the akropolis of Hellenistic Pergamon, where the radiating lines of the aisles of the theater of the third century (Figure 48) appear to organize and unify buildings and complexes above according to a dynamic, centrifugal impulse from the orchestra.[57]



47 Theater, Asklepieion, Epidauros. Ground plan. Drawing author, modified from A.W. Pickard-Cambridge, in Pickard-Cambridge 1946: Figure 70.



48 Theater, Akropolis, Pergamon. Third century B.C. View from the level of the orchestra. Photo author.

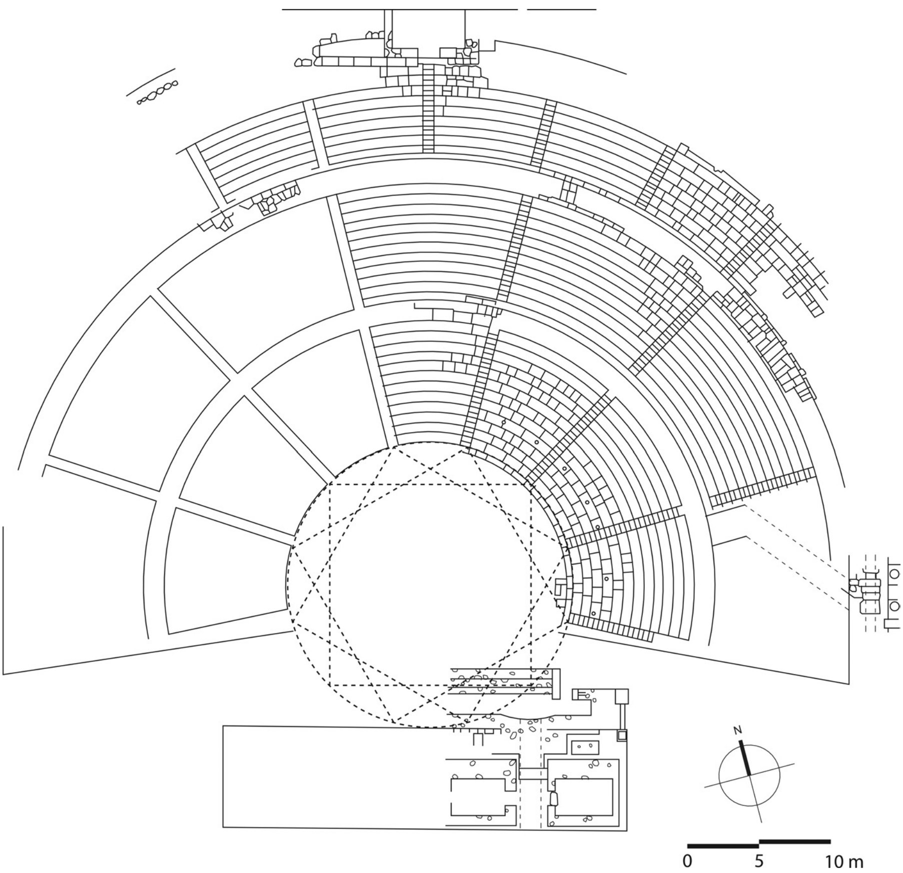


49 The Greek theater, according to Vitruvius (*De arch*. 5.7.1–2). Drawing author.

Whether as self-contained or integrating conceptions, the planar qualities of their designs transferred easily to natural slopes, creating the *koilon* or seating arrangement as a "hollow" that suggests the form of the sphere. Later the orthographic projections of Roman theaters like those of Pompey and Marcellus derive the cylindrical form of the *cavea*'s support, creating monumental urban expressions in elevation. As opposed to the sculptural expressions of temples, the experiential geometry of theaters emerges from the realm of ichnography.

The primary role of ichnography in Greek theater design finds support in Vitruvius (5.7.1–2). As opposed to the four triangles of Latin theaters, the planning of Greek theaters begins with a set of three circumscribed squares that establish the locations of *skene*, *proskenion*, and aisles, the latter again staggered in the upper tiers of seating (Figure 49). Although the shapes differ, the method of a radial and concentric design emerging from a geometric underpinning is the same.[58]

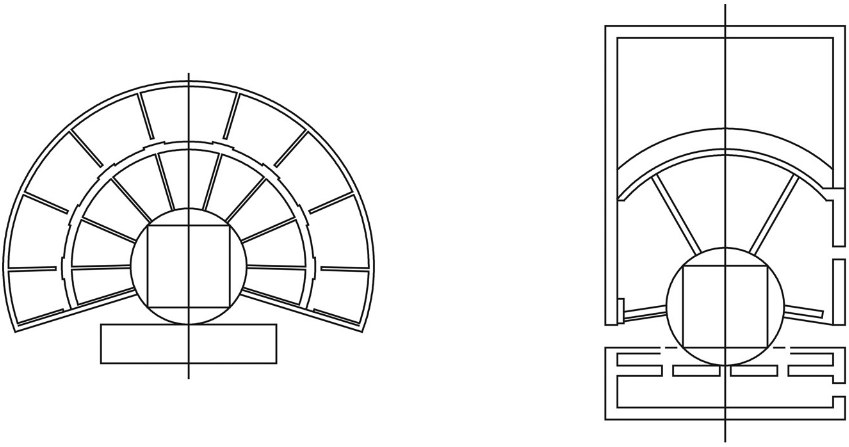
Vitruvius preserves for us only a theory for designing Greek theaters, which one may not expect Greek architects before him to have actually followed in any kind of formulaic way. Nonetheless, the method is recognizable in surviving works, ranging from creative variation to slavish reliance on the formula.[59] In the lower theater at Knidos dating to after the mid-second century, there is remarkable conformity with Vitruvius' description (Figure 50).[60] The same may



50 Lower theater at Knidos, after mid-second century B.C. State plan with addition of geometric underpinning of Greek theaters according to Vitruvius. Drawing author, modified from I.C. Love, in Love 1970: Figure 2.

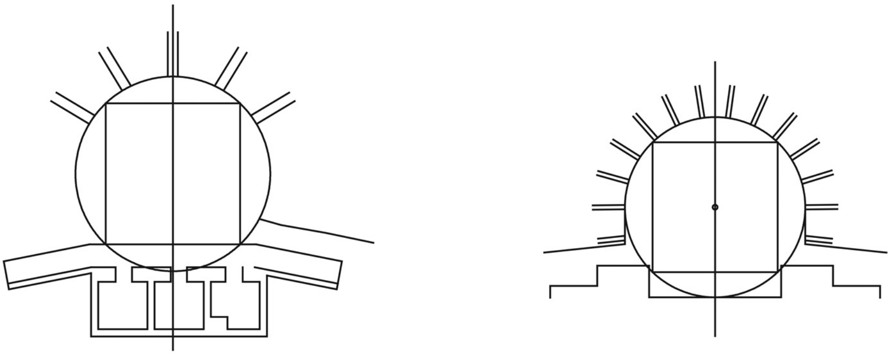
be said of the theater at Delos from the late fourth century (Figure 52.1). Contemporary with the Delian theater, the theater at Priene locates the *proskenion* and *skene* according to underlying geometry, but it does not integrate all of the radiating aisles within the scheme (Figure 53).[61] As analysis has demonstrated, there are in fact several examples from the fourth century onward showing variations on the basic scheme of the circumscribed square (Figures 51–52),[62] though I know of no other examples besides those at Delos and Knidos in which the aisles conform as well. Nonetheless, the pattern suggests that Vitruvius' Greek theater was no invention on the part of a Roman architect.

It has been asked whether Vitruvius learned of this procedure of design from an earlier or later Hellenistic source, with the latter possibility consistent with the traditions of building in Asia Minor and its offshore islands that Vitruvius relies on in his account of temples.[63] Of course, the lack of surviving architectural writing makes this a difficult question to answer, but it seems reasonable that



1. Kaunos, after mid-second century BC

2. Messene, Hellenistic



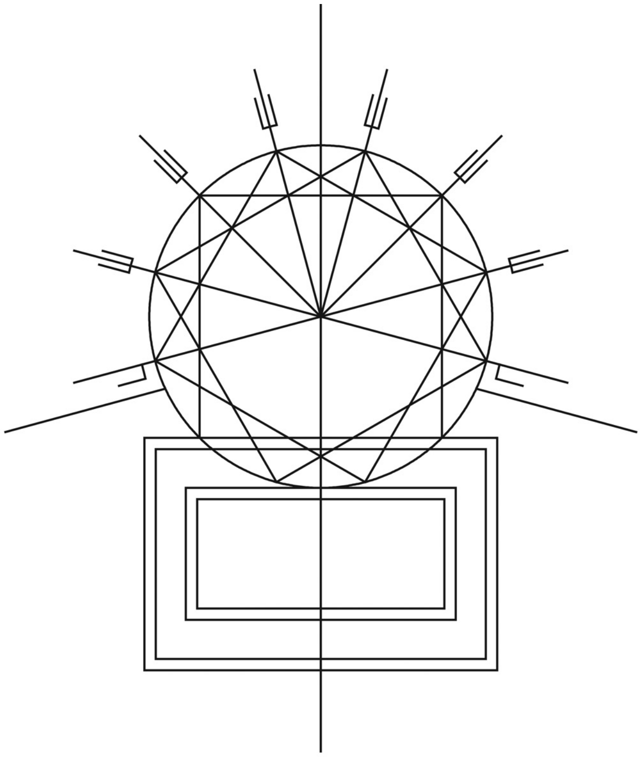
3. Demetrias, early third century BC

4. Theater of Dionysos, Athens, 370s BC

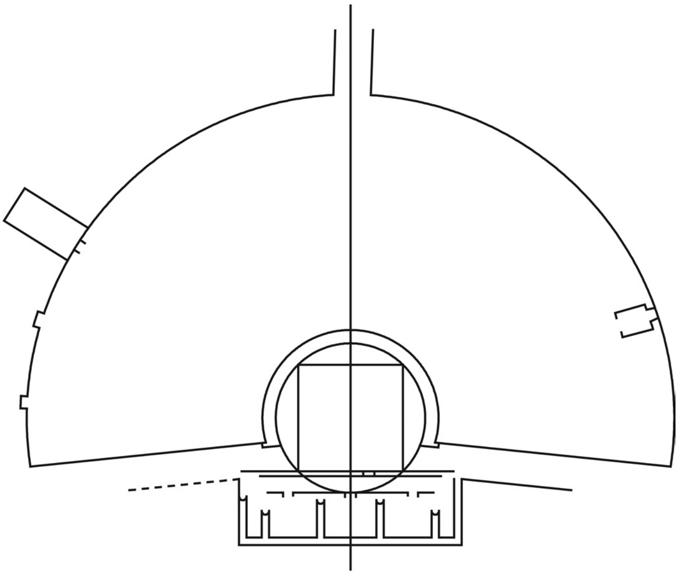
51 Diagrams of Greek theaters with their geometric underpinnings. Drawing author, after H.P. Isler, in Isler 1989: Figs. 5–8.

his direct source may have been a lost commentary of a later theater in the sphere of Asia Minor like that at Knidos (Figure 50).

For the present study, a more important question about the relationship between Vitruvius and his Greek sources pertains to what his discussion may reveal about technical drawing in the process of designing theaters. The geometry in the formula of the Latin theater lends itself to a different architectural composition for Roman theaters with respect to their Greek antecedents: a semicircular *cavea* and a deeper stage building whose front edge coincides with the center of the theoretical circle of the orchestra.[64] How does Vitruvius arrive at the changes to the geometry that, at least at a theoretical level, accommodate this different architectural type?



1. Delos, early fourth century BC



2. Iasos, early third century BC

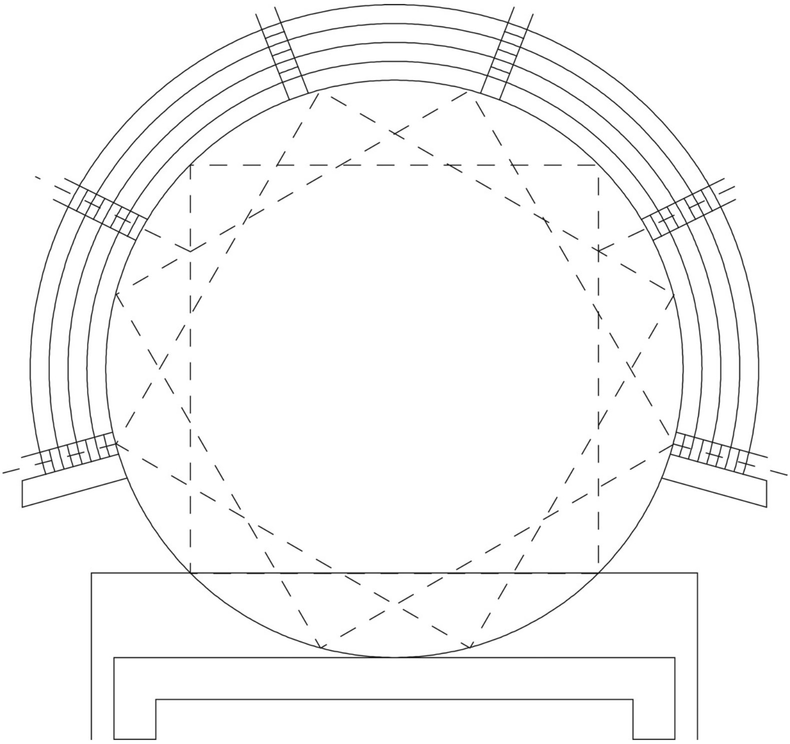
52 Diagrams of Greek theaters with their geometric underpinnings. Drawing author, after H.P. Isler, in Isler 1989: Figs. 9, 10.

The newer geometry is not as innovative as it may appear. One may recall how the Latin theater's geometry of the four circumscribed equilateral triangles results from simply connecting the circumferential intersections of a six-petal rosette with a straightedge. A second observation that we have yet to properly appreciate is that the geometric underpinning of three circumscribed squares used for the Greek theater is actually identical to that of the Latin theater. As Silvio Ferri has noted, the construction of Vitruvius' Latin theater is simply an extension of that for the Greek theater, with the latter appearing within its center.[65] In terms of the graphic algorithm that produces the Greek theater, then, it too results from straight lines interconnecting the intersections of the same six-petal rosette (Figure 42). In both cases, the same very basic drawing produces an operation of protraction based on angular divisions of 15 and 30 degrees. The form of the zodiac (Figure 35) that Vitruvius' interpolator relates to the Latin theater, then, applies to the case of the Greek theater as well. As we will see, the same form that shapes a sense of order into the universe operates in a related way in the city.

The story of the origins of the concentric, radial form of the theater and its relationship to the city begins with the Theater of Dionysos at Athens, built on the southern slope of the Akropolis (Figure 12). The construction of the limestone seating of the *koilon* with its capacity of at least 15,000 spectators appears to have commenced as early as around 370,[66] establishing the basic model of Greek theaters from that time forward. Before this permanent construction, the theater of Euripides, Sophokles, and Aristophanes of the fifth century was of wooden construction, and one cannot presume that its form anticipated the appearance of the theater of Menander in the fourth. More likely, its earlier *orkhestra* was rectilinear rather than circular, with its tiers of wooden bleachers rising in a similar rectilinear or trapezoidal fashion, or even just simple straight rows all roughly parallel with the front of the *orkhestra*.[67]

Before the Theater of Dionysos became Athens' main venue for rituals of spectacle, in the Archaic period, the Agora as the multipurpose city center seems to have carried this function as well.[68] According to literary sources, the Agora was the site of the *orkhestra*,[69] the name given to an area designated for performances. Its name relates to the verb *orkhesthai* – "to dance" – in a way that recalls the Spartan use of the alternative term *khoros* or "dance floor" for Sparta's own agora.[70] Here, the choral performances from which the famous tragedies evolved took place in front of audiences watching from the *theatron*, at first an informal area for *thea* or spectacle,[71] and later likely provided with *ikria* or wooden bleachers. A natural backdrop for such performances would have been the *skene*, the tent or hut of timber construction that operated as a changing room for costumed performances.

The other likely location of choral performances in the Archaic period was in front of the Temple of Dionysos near the southern slope of the Akropolis



53 Theater at Priene, late fourth century B.C. Restored ground plan with geometric underpinning. Drawing author, modified from A. von Gerkan, in von Gerkan 1921: Plate 29.3.

hill.[72] This site would have been the location of the Athenian festival of the City Dionysia. Here, the *ikria* would have faced the temple as a backdrop for the *orkhestra* in these early productions. In the early fifth century, the *ikria* collapsed. It is likely this event that influenced the move of the *orkhestra* northward to the base of slope to be used as a support for the rising bleachers.

In this location later to be occupied by the colossal permanent theater begun in ca. 370, Athens hosted the performances of the famous classical playwrights before audiences both Athenian and foreign. In a general sense, the spectacles of the City Dionysia created shared experiences of seeing (θεωρεῖν) on the part of the *theatai* or Athenian spectators and the *theoroi* or spectators sent from their respective *poleis* abroad.[73] More specifically, the Theater of Dionysos was the site of *theoria*, the ritualized and institutionalized witnessing of sacralized spectacles at a foreign city's religious festivals that was the central experience of *theoria* on the part of the *theoros*.[74] This Greek cultural activity involved the sending out of *theoroi* as ambassadors who journeyed abroad to see such spectacles and then return to their respective native *poleis* in order to give an account of what they saw.[75]

The relationship between this kind of ritualized seeing, philosophy, and the craft of building would have far-reaching consequences in the course of cultural production. This well-established practice was the model adopted by Plato in his account of *theoria* in Books 5–7 of the *Republic*.[76] The activity provided Plato with a way to describe the philosopher's journey into the intelligible realm to see the truth in the transcendent *ideai* and then return to report his experience in the manner of the escaped prisoner in the Allegory of the Cave (*Republic* 514–517). As I argue in the next section, the cultural practice of *theoria* in Athens that Plato drew on took place in the architectural setting of theater that shaped the experience of "theoretical seeing" in ways that Plato could take for granted in his account of vision and truth. As a related background, Plato's notion of the *ideai* is preceded by practices of architectural drawing at reduced scale with the compass and straightedge that crafted the form of space and seeing itself according to the same methods of technical drawing that constructed a sense of order in the cosmos. The metaphor of craftsmanship in the account of models in the mechanisms of the revolving universe already had fertile potential before Plato exploited it. In this way, the theater as the place for seeing dramatic performances preceded the account of truth and seeing in the "philosophical drama" of Plato's own dialogues.[77]

Central to my argument is a proposal that the circular and radial form of the Theater of Dionysos from ca. 370 onward reflects the general form of its immediate predecessor. I do not oppose the reconstruction of a rectangular *orkhestra* with straight rows of seats in the earlier phases of the theater. Yet it has already been suggested that the theater may have been remodeled sometime during the years of 420–410, although the possible design of this project has not been explored.[78] The evidence I will discuss for this project's design carries important implications for the question of ichnography and linear perspective in Athens in the fifth century.

THE THEATER AS THE CITY

At the City Dionysia of 414, the comedy *Birds* was produced.[79] This play survives as one of the masterworks of Aristophanes, the comic playwright in Plato's *Symposium*, even though it won only second prize.[80] Beyond the play's importance for Athenian drama, its commentary on contemporary life in Athens includes an underappreciated reflection of the planning of architectural space in the last quarter of the fifth century. The lines in question are 992–1020, in which a character named after the astronomer Meton makes his appearance as the pedantic would-be designer of a city for the birds.[81]

In the relevant lines, Aristophanes is clear in his descriptions of the procedures and tools of technical drawing. Upon Meton's entry, the play's protagonist Peisetairos asks him, "What's the *idea* of your design?" (τίς ἰδέα βουλεύματος.)

Here, Aristophanes employs *idea* some three decades in anticipation of Plato's metaphysically charged use of the term in his middle dialogues, and it would be wrong to read some kind of comparable meaning into its appearance in the context of Meton's drawing. Rather, Aristophanes' use of *idea* is common in prose.[82] In fact, the gist of Peisetairos' question may be simply, "What kind of project do you intend?"[83]

Still, the usage of *idea* in the line of Peisetairos involves some significant observations that have yet to be recognized. Given the context, one finds here a rather clear association with the process of making in a manner consistent with Plato's later observation that *ideai* are common in craftsmanship. Again, in the words of Sokrates, "And are we not accustomed to say that the craftsman . . . directs his eyes to the *idea* and thereby makes the couches on the one hand or the tables on the other, and other things that we use?" (*Republic* 596b). In adopting this metaphor for his intelligible archetypes, Plato would impart a philosophical connotation to them that, even in connection with architectural theory in the writing of Vitruvius, was likely as salient to the ancient reader as it is to us. More importantly, the use of *idea* to describe Meton's action that follows demonstrates its connection with the practice of architectural drawing. Whatever connotation that any writer or reader associated with the term at any period, Aristophanes' *Birds* shows an antecedent of the fifth century for Vitruvius' use of the Greek term to describe ichnography, linear perspective, and orthography (*De architectura* 1.2.1–2).

The dialogue that follows is fascinating. In response to Peisetairos, Meton remarks, "I wish to geometricize the air for you and divide it into sections" (γεωμετρῆσαι βούλομαι τὸν ἀέρα ὑμῖν διελεῖν τε κατὰ γύας).[84] Asked what he holds in his hands for this task, Meton says,

> Air rulers (κανόνες ἀέρος). First of all, the whole of the air is, above all, in the form (ἰδέαν) of a casserole lid (κατὰ πνιγέα). From up here I set down this ruler, which is curved (καμπύλον), insert a pair of compasses . . . and lay down a straight ruler and extend it across to make a circle quartered with an agora in the center, and so just like we have with a star – itself being circular – rays will beam out straight all around (999–1009).

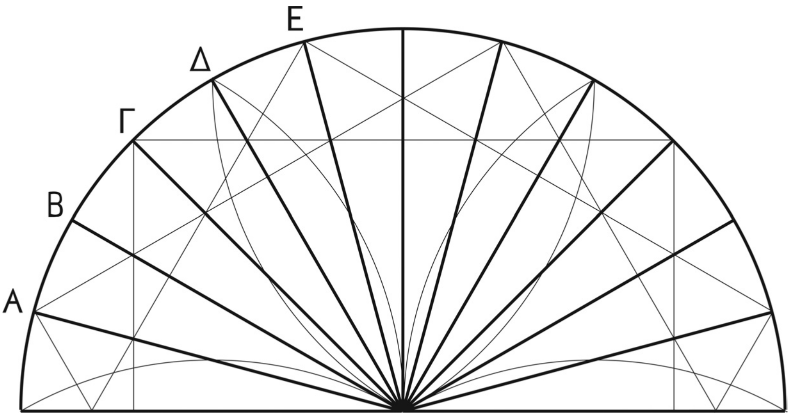
Following this speech, Peisetairos accuses Meton of being a charlatan, beats him up, and sends him away with the final insult that he should go elsewhere and measure out himself.

Several points in Aristophanes' lines require comment. Rather than translating πνἰγεύς as the kind of pressure-driven hydraulic vessel described much later by Hero of Alexandria (*Pneumatica* 1.42),[85] I follow Dunbar in envisioning a traditional hemispherical cover for a terracotta baking dish.[86] Although either is technically possible, for comedic purposes it is only the latter that might have struck the audience as familiar enough to have resonated. In taking this stance, I argue that Aristophanes' humor depends on a correspondence to reality whose bigger picture his audience could grasp, if not in minute detail.

To make sense of these lines, it is essential that we decipher the instruments that Aristophanes describes and how they are used. In Wycherly's reading, Aristophanes refers to a ruler, a compass, and a square.[87] The first two of these are obvious, but the latter requires explanation. If I understand his reasoning, he takes τὸν κανόν᾽ . . . τὸν καμπύλον to indicate a "bent" rather "curved" ruler, which would be justifiable on grounds of language. On the other hand, the square has no convincing application on the drawing board in the process that Meton describes, leaving Wycherly to posit the centering of the compass on the inner angle of the square to draw a quarter circle, followed by the removal of the square in order to complete the full circle. According to this idea, the termini of the initial arc would establish the locations for setting the straight ruler in order to extend straight lines through the center point, thereby allowing the circle to be quartered.[88] While perhaps not the most elegant method for this task, a more fundamental problem is that this explanation offers no clear means of carrying out the lines radiating out from the center all around – the streets that radiate out from the agora. More difficult yet is the question of how this procedure could have been acted out in a way that would have made any sense to the audience. According to Wycherly, the actor would have traced the figure on the ground (*proskenion*?), which would have been both impossible to see and exceedingly difficult to execute while delivering his brief lines.

According to Dunbar's reading, Aristophanes refers to a curved ruler that she reasonably envisions as a semicircular disc, or protractor.[89] According to this reconstruction, Meton holds the disk up to the audience, suggesting that this shape demonstrates the hemispherical shape of the air in section. Holding this curved ruler aloft, he then uses his compass and straightedge to draw the circle of the agora and the orthogonal and radiating streets on the air itself – all of this while gesturing with three instruments. Beyond the lack of clarity that such gestures would impart, one may doubt whether this act is even possible with only two hands. The resulting form that Meton describes, according to Dunbar, is a city that is semicircular in section after the half-disc of his curved ruler, which contains within it the circle of the agora from which the streets radiate skyward and earthward all around.

My own reconstruction offers a different interpretation of the instrument (κανὼν καμπύλος) in question. What Aristophanes evokes is a curved (and not bent) ruler, but contrary to Dunbar's proposal, its function in these lines bears a resemblance to its function in the real world. A protractor's application is not to serve as a template for the form of a half-circle, which is more easily accomplished at any size with just the compass and straightedge that Meton also has with him. Rather, in curving a ruler, the relevance of its measurements



54 Hypothetical Greek protractor or "curved ruler" indicating angular divisions of 15°. Drawing author.

shifts from the outer edge to the central point along its straight base (Figure 54). In other words, these measurements along the curve pertain to angles, and through the principle of radial protraction, a given angular measurement remains constant regardless of the radius of the instrument.[90]

Combined with the straightedge, the protractor establishes precise placements for radial lines projecting along a plane from a central point. Meton's application of these instruments involves the very action that he describes in his construction of a circular agora from which the streets project all around like the rays beaming out straight from a circular star, both radially and orthogonally. Keeping in mind that Meton describes the plan for a city, the function of protraction in his drawing is obviously an expansion of scale, a planar projection from the small to the large capable of extending into the real space of moving and seeing. In Athens in the year 414, Aristophanes describes a reduced-scale drawing based on the geometry enabled by the tools of technical drawing and presents it as an object worthy of ridicule.

Just as significant as the instruments and their applications is the form that Meton describes. The question of form here is not a pedantic one divorced from the comic purpose of Aristophanes' dialogue. Instead, it is the reason why it is funny. Speculation for the basis of Aristophanes' joke has ranged from Meton's impiety in studying the mechanisms of celestial phenomena,[91] to the accusation that Meton feigned madness in order to evade his military service obligations,[92] to the proposal that Meton here actually represents the famous urban planner Hippodamos, as though Aristophanes would satirize somebody by replacing him with somebody else entirely.[93] Aristophanes clearly makes fun of something, and there is no reason to doubt that his ridicule's focus includes Meton. Nonetheless, in fully considering how the joke works, one may pay more attention to the action performed in addition to the character who performs it. This action is the production of a form whose features are specified in the dialogue, though the audience's apprehension of these specifics would have required more visual aid than the props and gestures provided by Meton in the quick delivery of his lines.

One possibility deserving of serious consideration is that Meton describes *skenographia*, thereby directly referring to whatever was painted according to this technique on the *skene* immediately behind him. His description of his tools and construction of lines radiating from a center point certainly coincides with Vitruvius' characterization of *skenographia* as radial lines converging on the center point of a compass-drawn circle. Invented in the first half of the fifth century by the painter Agatharkhos, this method of illusionistic extension of the audience's visual rays into the scene would have been familiar enough for the joke to connect with the audience. In this interpretation, then, Meton would employ this sophistic-sounding theoretical technique in painting to the design of a city, creating an absurd, overly intellectual notion that is the basis of humor.

In addition to this first interpretation, I propose and favor a second. This second proposal does not replace the first, but rather extends and completes it. Although unprovable, for reasons that Chapter 3 makes clear, the larger arguments in the present study do not depend upon it. The cornerstone of the following interpretation, then, is its proposed chronology because it suggests an earlier development upon *skenographia* that, at the latest, undoubtedly took place by the time of the new stone construction of the Theater of Dionysos in ca. 370.

In a way that I believe the brief survey of Greek theaters in the prior section makes explicit, what makes Meton's geometric construction resonate with the audience it addresses is that it describes the theater itself in which he stands as he delivers these lines. His description of a concentric form with lines converging on and radiating out from the center matches both what Greek theaters look like and how Vitruvius describes the Greek theater as a geometric construction with the compass and straightedge (5.7.1–2). It is true that Meton's lines were delivered in 414, and we cannot confirm the appearance of the Theater of Dionysos before its expansion and remodeling in stone construction in ca. 370. On the other hand, there is no good reason to suppose that the later form did not resemble its immediate predecessor, built in timber on the lower southern slope of the Akropolis hill. If a new project during this period may have introduced the new circular arrangement into an institution whose form was traditionally rectilinear, it would have been in place for some four decades before its conversion to stone. In this scenario, the proposed circular version in timber might have been ripe for replacement and, more importantly, would have alleviated the radical boldness implicit in our current model that the new form makes its appearance without precedent in permanent stone starting in the second quarter of the fourth century. Moreover, it should seem strange that in a play performed in this same location, Aristophanes would so acutely describe only the later theater's form that neither he nor his present audience had any means of relating to. Indeed, Aristophanes is obviously satirizing something, and the notion that his actor's words and gestures were unable to point to anything that the audience could recognize would deplete this scene of its purpose and render the joke completely lost.

Since we have had difficulty in agreeing on the basis for the humor in Meton's lines, at the risk of suppressing all of its comedic force, I will detail a new explanation for the joke. The Agora in Athens was a place of convergence for people and activities sacred, political, commercial, and social. Traditionally it was even a site of spectacle, as indicated by its inclusion of an area designated as Athens' *orkhestra*.[94] In Aristophanes' *Birds*, Peisetairos wishes to escape from Athens and isolate it from its Olympian gods above by ruling over a city for the birds in the sky between, a position humorously reminiscent of the audience's location in the rising *koilon* between the plane of the city and its sanctuary on the Akropolis above. In referring to the idea of a geometric construction to create roads that converge on this celestial city's agora, Meton calls to mind – and almost certainly gestures toward – the pathways of the theater's aisles that converge upon the central *orkhestra* above which he stands. Meton's further statement that his scheme is like a circular star whose rays radiate out straight in all directions further equates the city he describe with the form of the theater where he delivers these lines. That Aristophanes should expect his audience to explode with laughter at Meton's expense may suggest that the notion of space designed in such a way was strange and new. This possibility may indicate that in 414, when this comedy was first performed, the shape of the theater – the shape that one today expects of a theater – was a very recent innovation, maybe even an entirely new remodeling for the City Dionysia of that year.

The City and the Cosmos

If, as I suggest here, Aristophanes' Meton does not serve as an oblique reference to Hippodamos of Miletos, the comedic role of an astronomer who shapes architectural space deserves explanation. Interestingly, when Vitruvius defines *architectura*, he does so not just according to the art of building, but also timepieces and machines. Book 9 is largely devoted to astronomy, and the universe is characterized as a cosmic mechanism created by an architect, just as machines themselves imitate the turning of the cosmos. In Athens, Meton himself was a maker of sundials,[95] an activity that Vitruvius would later designate as one of the three departments of architecture. These coincidences do not go so far as to evidence some kind of continuous tradition stretching between Athens in the fifth century and Rome in the first. Still, our loss of Classical and

Hellenistic architectural written commentaries makes this possibility difficult to exclude. In addition, the parallels between Plato's divine craftsman and Vitruvius' architect of the universe do suggest some kind of discourse on building and the cosmos that is recognizable in lines 992–1020 of Aristophanes' *Birds*. In addition, long before that, Anaximander's geocentric cosmic sphere features the earth supposedly in the form of a column drum.[96] Beyond this question of continuity and its transmission, these coincidences suggest that our own strict division between astronomy and building is not necessarily natural – a realization underscored by the inclusion of the design and mechanisms of the universe in the earliest definition of architecture. It should therefore cause us little difficulty in considering how an Athenian audience in the Classical period may have identified with the notion of an astronomer and maker of sundials in the role of architect.

With respect to his namesake in *Birds*, the real-life Meton's known activities leave us no indication of any accomplishments in the realm of building other than sundials. In 432, he and Euktemon observed the summer solstice in order to more accurately measure the length of a year.[97] He was also the discoverer of the Metonic cycles of the moon that bear his name, equal to a nineteen-year interval between the reappearance of the moon at both a given point in the sky and an identical phase.[98]

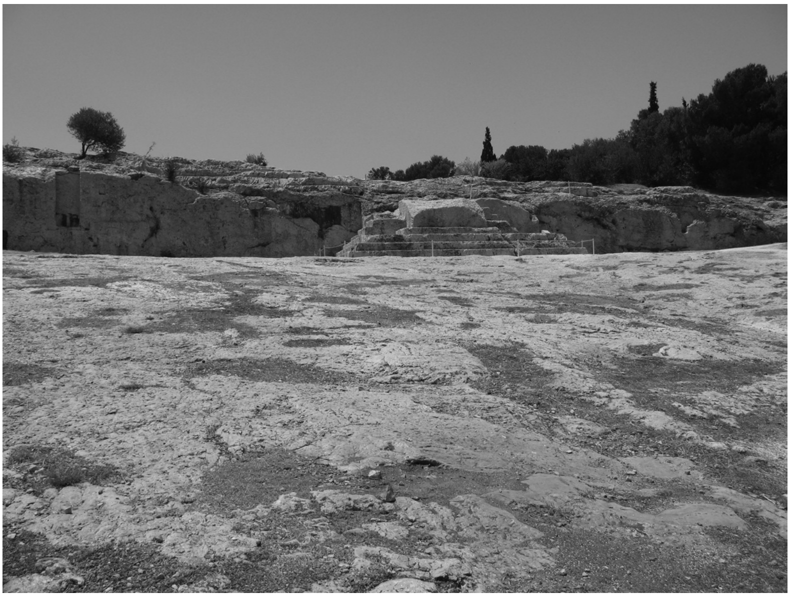
There is, nonetheless, a parallel between the kind of technical drawing that Meton would have engaged in and the geometry that his fictional counterpart describes. In conjunction with his observation of solstices and along with Euktemon and Demokritos, he used *parapegmata*, the astronomical calendars that allowed him to set precise lengths for the seasons and year. *Parapegmata* divide the year into twelve equal parts – a division that emerges out of the zodiac as a circular construction with twelve signs based on equal angular divisions of 30 degrees (Figure 35), which first appears in Greek astronomy in the later fifth century along with the *parapegmata* of Meton, Euktemon, and Demokritos.[99]

One may recall how Vitruvius or his interpolator remarks how the same algorithm of circumscribed triangles creates both the Latin theater and the zodiac (Figures 35, 41) – an observation with far-reaching consequences. As discussed earlier, this procedure is identical in the Greek theater wherein circumscribed squares determine the building's form through the principle of protraction, resulting in twenty-four equal divisions of 15 degrees (Figure 49). Of course, the circumscribed square quarters the circle in the way that Aristophanes' Meton proposes to "lay down a straight ruler and extend it across to make a circle quartered with an agora in the center, and so just like we have with a star – itself being circular – rays will beam out straight all around." The focus of Meton's lines and Vitruvius' descriptions of theaters is not the construction of squares, but rather the squares that result naturally through an identical graphic algorithm executed in the formation of an ideal city or theater. The design of the Greek theater and the instrument of the "curved ruler" (Figure 54) that facilitates it are products of the same application of the compass and straightedge that construct the zodiac, an observation made more interesting by the fact that it is an astronomer whose urban design resembles no city, but rather the theater in which he stands. The kinship between the circular, radial forms of the theater and zodiac is such that Vitruvius (9.1.5) would later employ the former as a metaphor for the latter in describing the turning mechanisms of the cosmos (Figure 44).

Meton's city of the birds is an idea imitative of no city, but it stands at the beginning of a venerable tradition. Though it may have been impractical to build the circular and radial utopias dreamt and sometimes built for Early Modern cities like Palmanova, the Place de l'Etoile in Paris, and the Prati region in Rome, the idea itself would occur again even in the Classical period. In his *Laws* (778c), Plato describes the form of a similarly idealized city as circular in plan, a form that in the *Critias* (115c) also characterizes Atlantis as a concentric idea with interconnecting linear canals and bridges through belts of water and land that may reflect a reduced-scale graphic conception of built space constructed with the compass and straightedge. Again, the sense of order given to the diagram appears to evoke the circuits describing the pathways of revolving bodies around a central earth, recalling what for Plato may have been the notion of the city as an imitation of the cosmos.[100]

In the actual city of Athens, the traditional multipurpose character of the Agora as the place for assemblies of all sorts began to break to down with not just the decline of its *orkhestra* in favor of the Temple of Dionysos at the southern edge of Akropolis, but also the establishment of the larger open space of the Pnyx hill as the site of its *ekklesia* or general assemblies. Starting at the beginning of the fifth century, these assemblies involved the unprecedented gathering of 5,000 or more male citizens to carry out the functions of Athens' new political system of democracy.[101] Although physical evidence of the form of the Theater of Dionysos in the fifth century does not survive, there were two related formal developments on the Pnyx that are visible today. First, in the 430s, Meton built a sundial whose foundations have been recognized.[102] Secondly, at the end of the fifth century, following the reconstruction of the Theater of Dionysos before 414 as proposed here, a retaining wall defined a new semicircular shape for the Pnyx where all sight lines converged on the *bema* or speaker's platform exactly located on the central axis defined by the location of Meton's sundial just behind (Figures 55, 56).[103] The semicircular form and central visual focus of the late-fifth-century Pnyx resemble the basic appearance of the Theater of Dionysos of ca. 370, which in the course of the fourth century came to replace the Pnyx as the site of Athens' political assemblies.

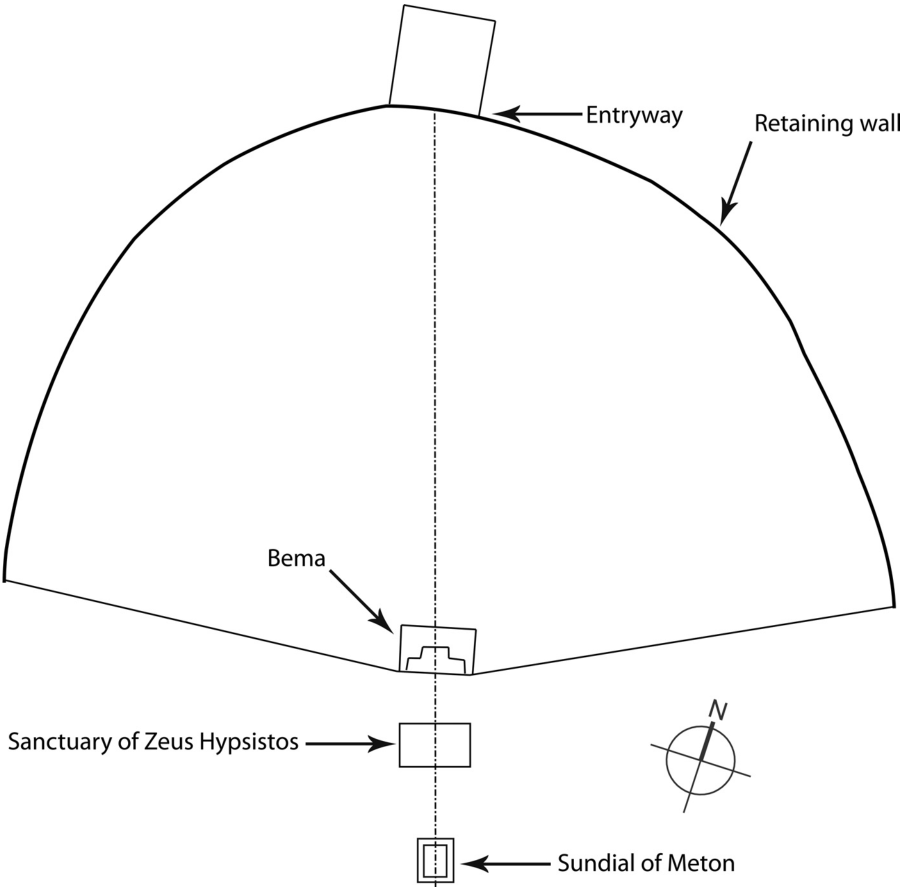
In the form of Meton's sundial and Aristophanes' representation of him in *Birds*, the coincidence of the Athenian astronomer's real-life and fictional central



55 Pnyx, Athens, phase III, end of fifth century B.C. View from *koilon* toward bema. Photo author.

presence in both locations is perhaps fortuitous but nonetheless appropriate. On the Pnyx, Meton's sundial establishes the central focus of the audience's sight lines. In the Theater of Dionysos, Meton articulates how the central focus is like a star whose rays beam outward, and therefore radiate toward the audience. A common tenet of Greek optical theory in traditions preceding and following Aristophanes' *Birds* is the radiating of light from the eye, its coalescing with external light around the object beheld, and its return to the eye.[104] Like Euclid's later cone of vision that relates to this schema, the theater captures this centripetal and centrifugal act of vision itself that characterizes both Aristophanes' description of the city through Meton and the description of one-point linear perspective invented for the theater in fifth-century Athens. In presenting the city with its streets, agora, and civic gatherings in this schematic fashion, perspective itself was political, an act of positioning subjects and binding them within the construction of *thea*, the idea of seeing and being seen in relation to the whole and its center.

As we commonly recognize, the *theatron* was a place for *thea* or seeing, but in this etymology one should recognize that seeing in such large-scale urban gatherings like those of the Theater or the Pnyx necessarily involved being seen.[105] This quality of the gaze is emphasized by literary accounts of the attention generated by particular members of the audience in the theater or the manner of voting on the Pnyx that put tribal and individual votes on unabashed display to the entire gathered assembly.[106] In exposing subjects, such



56 Pnyx, Athens, phase III. Simplified plan. Drawing author.

objectification inscribed them within normative roles as citizens and invited foreign viewers engaged in specific and institutionalized practices of seeing.

There are interesting parallels shared between such viewing and Greek descriptions of drawing. Again, in Plato's account of vision, an emission of rays of light from the eye unites with the light of the world, forming a corporeal connection between subjective and outer light, as well as the object viewed. In Meton's lines, rays emit from the center like a radiant star, suggesting an independent origin of projection that corresponds to the object of focus for the sightlines of the audience in the *koilon*, binding *theatai* and *theoroi* into a unified, collective experience of spectacle in which performance and its perception express a concrete form. This form – the *idea* of Aristophanes' Meton – radiates from a compass-drawn circle as its center or "agora," and the active centrality of this space as the theater's *orkhestra* would become for Vitruvius (and possibly his Greek sources) a model for seeing the revolutions of the cosmos. According to this model, the perspective is that of the center looking outward to see the entirety in the manner of Jeremy Benthem's Panopticon, in this case that of the earth. In Euclid's proof for the geocentric cosmos and its related diagram (Figure 34), similarly, it is the earth-bound viewer whose eye emits its visual rays toward the stars, themselves organized according to their signs as an equal twelve-part radial division reminiscent of the twelve- or twenty-four-part Greek theater that Vitruvius describes.

Beyond any variations in these models for the zodiac and the theater, there is an important geometric constant: the construction of a circle with its radial lines converging on a central point. That Plato's account of vision and its related institution of *theoria* as an activity centered on the Theater of Dionysos should also lend itself to this construction need not have been conscious or intentional. Rather, I would argue, this form was the model available as the site of *theoria* and the shaping of cosmic order for the eye to grasp in diagrammatic form – a shaping that Aristophanes so appropriately assigns to an astronomer who crafts urban space. From Meton to Eudoxos to Euclid and beyond, the shared practices of technical drawing in astronomy and optics resembles the graphic art of constructing spaces for communal viewing.

The further resemblance between this circular, radial design for the theater and linear perspective in painting as described by Vitruvius is especially interesting. His identification of Agatharkhos as the inventor of *skenographia* in the first half of the fifth century would place its existence before the geometric form that Aristophanes' Meton describes.[107] An art historical criticism against this early date for the invention of one-point linear perspective is the lack of any reflection of its application in painting before a much later date,[108] although it is unclear as to why one should expect paintings on the small, convex surfaces of vases to have imitated a technique intended to create realistic settings for dramatic performances.[109] Furthermore, any limitations perceived in the proper theoretical grasp of a single vanishing point in the surviving wall paintings in the Campania and Rome should not exclude its proper application in its original context in Greece during the Classical period.[110] The geometry shared between the circular, radial construction for *skenographia* in the theater and the shape of the theater itself, which I suggest Aristophanes describes in 414, invites us to speculate on the possible influence of the former on the latter. If such was the case, both linear perspective and the practices of drawing would have theorized *thea* in ways that shaped the *theatron* specifically as a place for seeing. In the sense that both linear perspective on the *skene* and its analogous graphic construction for the *orkhestra* and *koilon* are both geometric underpinnings or rationalizations rather than the experience of seeing itself, they may be understood as *ideai* in that they allow one to see (ἰδεῖν) *thea* through its theoretical inner workings. The painted compositions for the backdrops and the structure of the seating and aisles built into the rising hollow of the hill, then, represent the *ideai* drawn at reduced scale, to which the craftsman as painter or architect directs his eyes in the making of these works in real space in the related manner described by Plato in his metaphorical discussion of the Ideas (*Republic* 596b).[111]

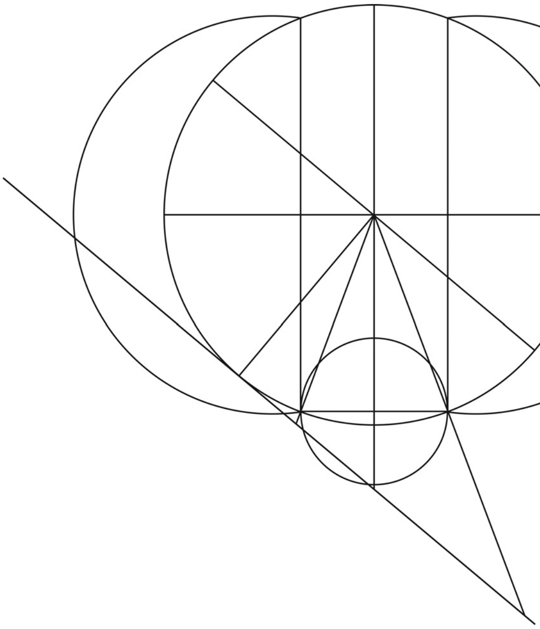
Also in regards to Plato's divine craftsman and its apparent progeny in Vitruvius' architect of the cosmos, astronomy may provide a meaningful background for philosophy and architectural theory. Just as the theater represents seeing itself as constructed in its ichnographic *idea*, for Vitruvius it becomes a model for envisioning the revolutions of the planets along the circuits of a circular stairway passing through the signs of the zodiac, itself constructed graphically by the same means as the theater. For Plato (*Republic* 529c-e), we are to treat the mechanisms of the revolving cosmos as *paradeigmata* or models of intelligible reality rather than eternal truth itself, just as we would the beautiful geometric diagrams of Daidalos or another skilled craftsman or painter. In a way that may be more apparent following the present chapter's consideration of technical drawing for the theater and astronomy, then, Plato's allusion to the diagrams of a craftsman in reference to cosmic mechanisms is not such a departure from astronomical representation. Rather, the reference to drawing in craftsmanship fits the context of his discussion of the movements of the stars that are commonly understood through cosmic diagrams, although Plato's use of the general term "craftsman" rather than "architect" still requires explanation through detailed considerations of drawing practices in the next chapter. Secondly, the appropriateness of his inclusion of the geometric diagrams of painters specifically in this context also becomes clear, as geometry finds its application in the circular, radial underpinning of *skenographia* in a manner akin to cosmic diagrams.

In noting these connections, it would be unnecessary to posit that Plato would have thought through the formal similarities common to technical drawing in craftsmanship, painting, and astronomy. More likely, he would have simply had in mind the forms of graphic construction with the compass and straightedge, referring to Daidalos, craftsmanship, and painting to emphasize the beauty of such drawings, thereby allowing him to distinguish between beauty and absolute truth as embodied by the real velocity of movement at an intelligible level. For our purposes, the significance of pairing drawing in craftsmanship with the revolutions of the stars is that the similarity was apparent enough to lend itself naturally to an astronomical reference, just as Aristophanes could send Meton to the stage to design a city. Similarly, in Vitruvius' later discussion of sundials – an expertise of Meton – he would describe the *analemma* (Figure 57) as a graphic figure that reveals the movements of the sun in the universe through a pair of compasses and a kind of reckoning that is "architectural" (9.1.1), just as nature itself formed the revolutions of the cosmos as an architect (9.1.2). In Aristophanes and Plato both, one sees reflections of the centrality of drawing in the related activities of craftsmanship, astronomy, and mechanics that would later receive the common designation of *architectura*.

Despite our difficulty in securely recognizing ichnography at work in temples of the fifth century and earlier, the relevant lines of Aristophanes' *Birds* leave no doubt of its application in Athens by the year 414. In Aristophanes' ideal city and, I argue, the design of the Theater of Dionysos that this imaginary form referenced, it preceded its readily apparent application in the concentric, radial tholoi of the fourth century like those at Delphi and Epidauros.

As discussed at the close of Chapter 1, however, the question of where and when the first ichnography was drawn may be less interesting than the question of when ichnography became architectural. In other words, regardless of whether the architects of Archaic or High Classical temples may or may not have drawn ichnographies, there may be a difference between these earlier examples and later practices informed by a rigorous application of theory. This theory, according to Vitruvius, is established by a set of Greek terms (*taxis*, *diathesis*, *eurythmia*, *symmetria*, *oikonomia*) that describe the principles of which *architectura* consists, and which find their application in the *ideai*: ichnography, linear perspective, and orthography (1.2.1–9). In addition, *architectura* is defined by three parts: the art of building, clock making (including the astronomical-based art of sundials), and machinery (1.3.1). In a way that Vitruvius makes explicit, the latter two of these divisions reflect or make visible the sense of order in nature's mechanisms.

In the following two chapters, I explore how the art of building as the first of these divisions may have been formative in the shaping and seeing of this sense of order. As the first activity to shape order in the Greek world, the art of building provided the model for order in the cosmos, creating a correspondence between building and nature through principles and techniques of drawing. This correspondence was indeed strong enough for the reverse to appear true to Vitruvius: That it is the building that reflects ideal nature rather than the other way around, as in the temple designed according to the principles of the ideal human body (3.1.2). Yet the ideal is the product of the *idea*, the contrivance of ichnography, linear perspective, orthography, and, as I argue later, the working practices of full-scale 1:1 drawing that are the ancestors of reduced-scale drawing in Greek building. As I discuss in Chapter 3, the transition from 1:1 to reduced-scale drawing was a function of seeing, or more specifically of envisioning seeing, in which the traditional instruments and techniques of drawing at full scale find expansion through protraction, encompassing and ordering space in the manner described by Aristophanes' Meton. As suggested in the chronology of innovations at the Theater of Dionysos, ichnography was born of linear perspective, thereby reflecting this theory of vision. Yet as an ordering of space according to the experience of the viewer, linear perspective itself followed a pattern for order already existing in building, as did the cosmic diagrams that represented the ultimate reduction of scale in the contraction of the universe to a form small enough to construct with the compass and straightedge.



57 Graphic form of the *analemma* as described by Vitruvius (*De arch.* 9.1.1). Drawing author.

Craftsmanship, Painting, and Plato's Diagrams of Daidalos

Up to this point in the present study, Plato has served as a source for approaching the topic of architecture as viewed through a Vitruvian lens, a view that is perverse to both Plato's time period and philosophical aims. In this final section of the chapter, I briefly address some of the implications of the material explored here for an interpretation of the impact of craftsmanship on Plato's intended expression. As discussed in Chapter 1 in particular, the value of the metaphor of craftsmanship is obvious in the *Timaeus*, where the divine craftsman's models and products, as well as the role of vision in intuiting them, are integral to Plato's philosophy. With the benefit of the analysis in Chapter 2, one may newly approach the *Republic* as an incipient expression of Plato's thoughts on the craftsmanship of his own time that served him in a positive way.

Looking back at the *Republic* in the *Timaeus*, Plato characterizes his earlier volume metaphorically as a painting (*Timaeus* 19b-c).[112] In this regard, it is interesting that in the *Republic*, Plato remarks that the final culmination of the philosopher-ruler's philosophical education would be his newfound ability to open the eye of his soul to the Idea of the Good, which is to be his *paradeigma* (*Republic* 540a). Earlier in the same text, he compares philosophers to painters and similarly remarks that the goal of philosopher-rulers is to trace out the city's form like painters who turn to a divine *paradeigma* (484c, 500e–501c). Furthermore, he compares his ideal city to a painter's *paradeigma* of human beauty (472d), suggesting through reference to painting that, metaphorically speaking, the ideal city's form follows a *paradeigma* that is unlike the form of any actual city.

The *paradeigmata* of painting to which the *Republic* refers are ideals or *ideai* in the manner of the Idea of the Good, a point made explicit at 540a. In turn, Plato portrays the Idea of the Good as that which illuminates the intelligible realm (508e), just as it is the source of the illuminating power of the sun and of truth and beauty in the phenomenal realm (517b-c). The "upward seeing" as an active emission of rays from the eye of the soul and the complementary penetration of such rays into the soul – the way of seeing the beautiful through geometry (527b) or astronomy (529b) – leads one to give birth to intelligence and truth, and hence knowledge (490b).

In a further elaboration in the *Timaeus*, Plato distinguishes between two kinds of *paradeigmata*: the eternal models of the divine craftsman and the generated models of becoming that imitate the eternal ones (*Timaeus* 27d–28a, 28c–29a, 48e–49a). The *paradeigmata* of the second kind are those of the "common" (rather than divine) craftsman or painter, as in the astronomical discussion in the *Republic* where the diagrams of Daidalos or another craftsman or painter are geometric drawings that are "most beautiful," though unable to convey truth itself (*Republic* 529e–530a). Like his prior discussion in the passage on the "Divided Line" establishes, however, recognizing the limitations of the craftsman or painter's geometric *paradeigma* is no condemnation. Rather, geometric drawing in the everyday, common world provides the understanding that propels one toward the apprehension of truth in the intelligible realm of the Ideas (509d–511e).

Why Plato should mention a painter along with a craftsman in a discussion of geometric drawing may be easily accounted for. Already in the fifth century, the *paradeigmata* of the monumental painter involved the graphic technique of radial protraction developed in other craftsmanship. Like the designers of temples and sundials, then, the inclusion of painting in a reference to geometric drawing in craftsmanship would be natural. Unlike traditional designers, however, this employment of radial protraction was for a purpose explicitly connected with vision, which was a theme of great importance for Plato's adoption of the metaphor of *theoria*.

If we may draw our attention to the rituals behind this and other metaphors that would be more familiar to Plato's intended audience, new meaning emerges. As Simon Goldhill recognizes, the dialogue of Classical drama is replete with references to seeing.[113] Such language is integral to two of the central purposes of performances in the Theater of Dionysos: the education of Athenians as *theatai* in the new era of democracy and, even more relevant to Plato, the rituals of *theoria* as a visual encounter with truth and accounting of this experience.[114] Like the dramas that such performances are based on, Plato writes works wherein a set of characters engage in dialogues.[115] In addition to this suggestion of performance, Plato calls his *Republic* a painting and evokes painting and its *paradeigmata* in his descriptions of the aims of his newly invented institution of *philosophia*. By doing so, he presents the *Republic* as a work that, like a drama, explicitly calls out to be looked upon and at the same time offers a new way of seeing explained through reference to geometry that draws *theoroi* into his account of his otherwise incomprehensible realm of Ideas through their own experiences. Calling his readers out and away from their everyday existence as citizens of the city that executed Sokrates, his Athenian readers become *theoroi* to whom he offers the possibility of transformation by looking upon truths that shine forth like the sun, blinding at first but capable of penetration into one's soul in the generation of intelligence and beauty that can make one a philosopher fit to rule in his ideal city.

The similarities between Plato and Aristophanes are worth considering. Illuminated by the Idea of the Good toward which the philosopher-ruler opens his soul's eye like the *paradeigma* on which the painter bases his composition, the ideal city thus delineated will be unlike any existing city. In a parallel way decades before, Aristophanes sends onto the stage Meton, whose *idea* is also that of the painter's *paradeigma*: a construction with the tools and methods of radial protraction that, like a star, will beam out straight all around. Also like Plato's ideal city, Meton's form for the city of the birds is unlike any existing city, made of the graphic device for vision in the place designated for *theoria*.

In our own comparison of these accounts side by side, it would be absurd to posit the influence of Aristophanes on Plato. More meaningfully, one may consider how the careers of these two very different writers overlapped as products of the same environment of cultural production in Athens of the Classical period. Their respective expressions thereby relied on the same set of institutions and other factors from which their references and metaphors could be drawn to describe the form of a city unlike any actual city, and standing as an alternative and even a rival to Athens. In the hands of Aristophanes, the expression is farcical and fleeting. For Plato, it is earnest and a subject to be laid out across volumes of dialogue. In this sense, the observable parallels in Aristophanes and Plato cannot begin to overcome the distance between them. Rather, the commonalities are limited to a dependence on the same metaphors of craftsmanship, ritual, and inquiry into the structure of the universe that define their shared time and place.

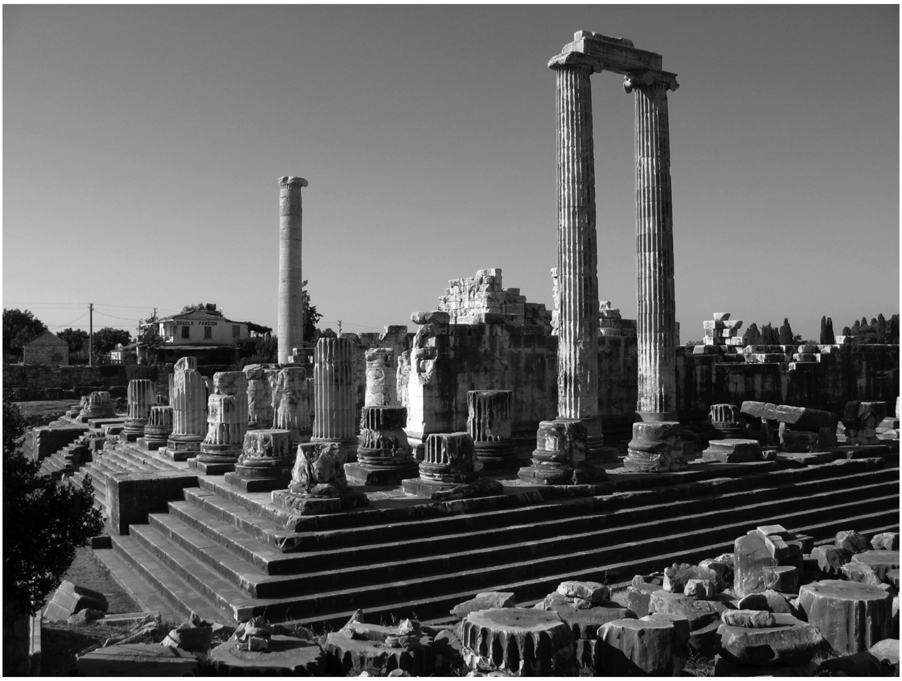
THREE

THE GENESIS OF SCALE DRAWING AND LINEAR PERSPECTIVE

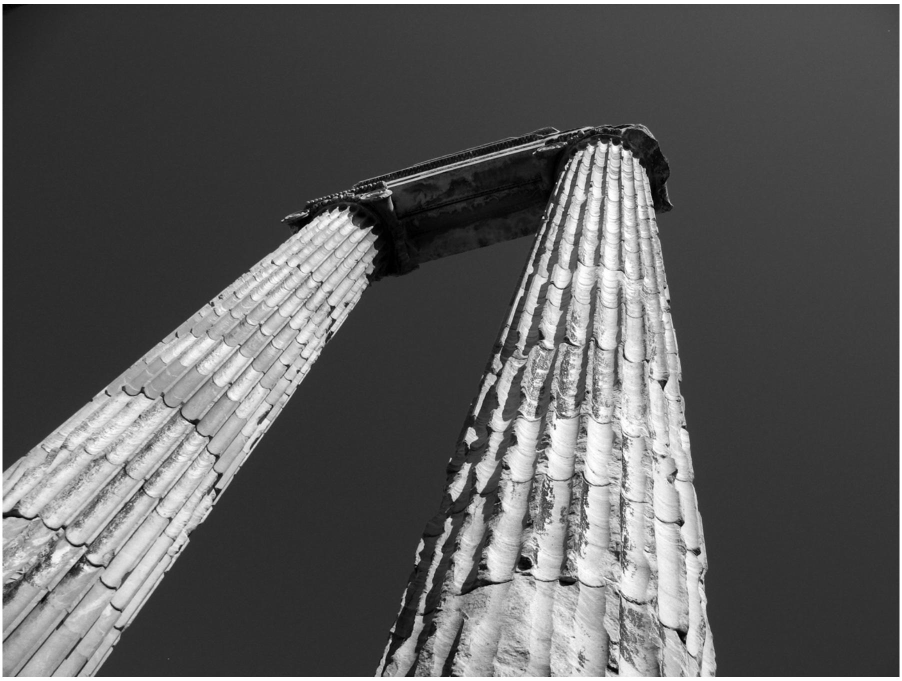
As explored in the previous two chapters, analyses of both texts and buildings may be helpful in interpreting the origins of linear perspective and ichnography. Ultimately, however, these analyses must also integrate what may be learned from preserved drawings and how such drawings may have functioned in the process of designing buildings and their features. The present chapter addresses surviving and hypothetical drawings and their respective roles in design, arguing that linear perspective and ichnography were born of the instruments and techniques first explored in graphic methods of constructing individual elements and refinements. Against the background in philosophy, optics, and astronomy discussed up to this point in the present study, it also considers the contributions of such tools and techniques to the construction of the very notion of order in both nature and the viewer's perception of it.

Single-Axis Protraction

Direct evidence for ancient Greek architectural drawings is limited by the perishable nature of graphic representation. Although whitewashed wooden tablets, papyrus, or parchment would have made for suitable if expensive surfaces for drawing, it is to our disadvantage that these materials have not endured.[1] We are therefore fortunate that Greek masons and architects also worked out their forms on-site on ashlar blocks. Upon covering these surfaces with red pigment, the use of a graver with a straightedge and compass rendered drawings whose white linear incisions stood out with clarity against their surrounding color.[2] Masons later intended to polish these blocks upon the completion of construction. Projects like the colossal Hellenistic temple of Apollo at Didyma (Figures 58, 59) never reached completion, however, and it is here that



58 Hellenistic Didymaion. General view from northeast. Photo author.

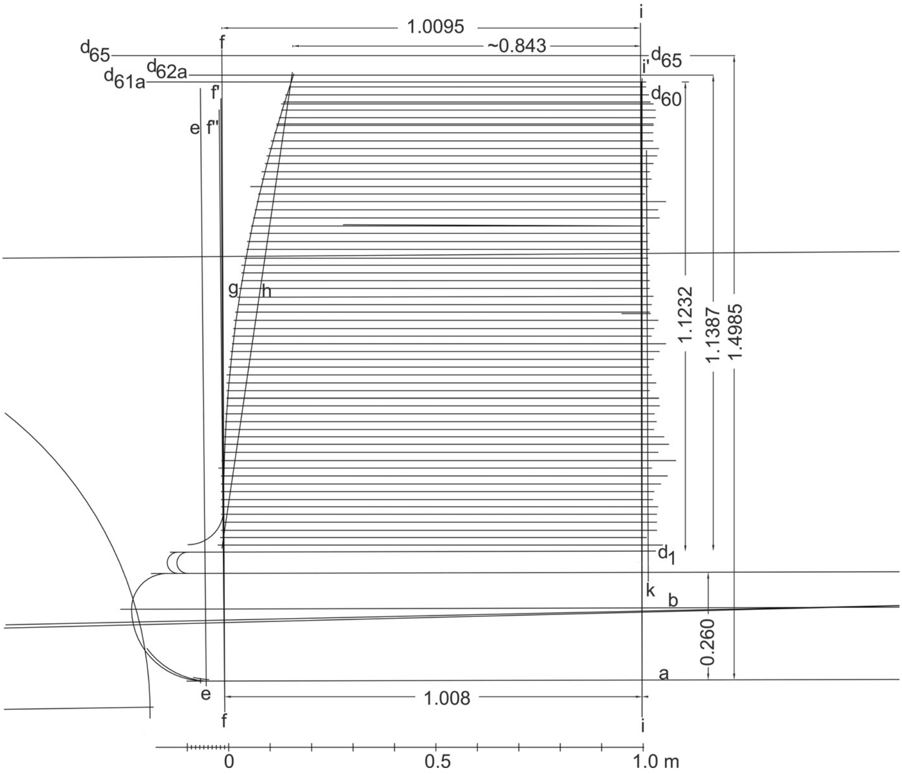


59 Hellenistic Didymaion. View of columns from below. Photo author.

Haselberger made his now famous discovery of Greek blueprints. Incised designs created over the course of approximately half a millennium starting in the third century cover approximately 200 square meters of the walls of the Didymaion's adyton.[3] Classified as "working drawings," most of these designs demonstrate the working through of architectural details at full scale. Among these drawings at Didyma, however, there are two important exceptions that may provide useful considerations in a larger theory of how reduced-scale drawing first came into practice in Greek building. In this chapter, then, an analysis of these blueprints opens new insights into the role of number, geometry, and the principle of protraction in the invention of linear perspective and ichnography.

On the north wall of the Didymaion's adyton just to the right of the north tunnel upon descending (Figures 8–10), there are two related blueprints drawn for the construction of the shafts of the temple's colossal columns rising 20 m above the stylobate (Figure 33), both of which would have been completed by the middle of the third century.[4] As their discoverer Haselberger discerned, these drawings include the radial construction for the fluting of drums on the left and, on the right, a section drawing of a column that preserves the procedure for the working out of entasis. Entasis, roughly meaning "tension," refers to the subtle curvature of a column's profile so that, as Vitruvius recommends, the curve reaches its maximum rise near the middle of the shaft (*De architectura* 3.5.14).[5] Commonly found in the columns of Greek temples from the Archaic period onward,[6] the degree of curvature varies significantly from monument to monument. This refinement imparts an organic, even breathing quality to the column, replacing the potentially cold lifelessness of a straight post and lintel with the effect of something like a muscular expansion in response to weight bearing.[7] As Vitruvius explains, furthermore, entasis is a response to the requirement of vision, whose habit is to seek beauty (3.3.13).

Without question, Haselberger's recognition and explanation of the procedure found in the blueprint for entasis (Figure 60) represents one of the most far-reaching contributions to modern research on the design and construction processes of Greek architecture. Before this discovery at Didyma, the method for working out entasis had remained completely mysterious, and numerous attempts to reconstruct it go back to the early sixteenth century.[8] None of the solutions ever offered retrieved the simplicity and ingenuity of the Hellenistic method that Haselberger elucidates, drawn by an ancient architect on the adyton's walls in order to design the temple's majestically rising colossal shafts. At full scale, the curvature would have been impossible to construct with the available tools for technical drawing, since a radius of almost 900 m would have been required. In section, therefore, the architect drew at 1:1 scale the thick shaft from the central axis (*i*) to the curved outer profile (*g*), a dimension of ca. 1.01 m to the outer profile before carving (*f*). Its height, however, is compressed to one-sixteenth of the height of the actual columns to be erected. The rationale



60 Hellenistic Didymaion. Restored blueprint for entasis (detail of Figure 33). Drawing author, modified from L. Haselberger, in Haselberger 1980: Figure 1.

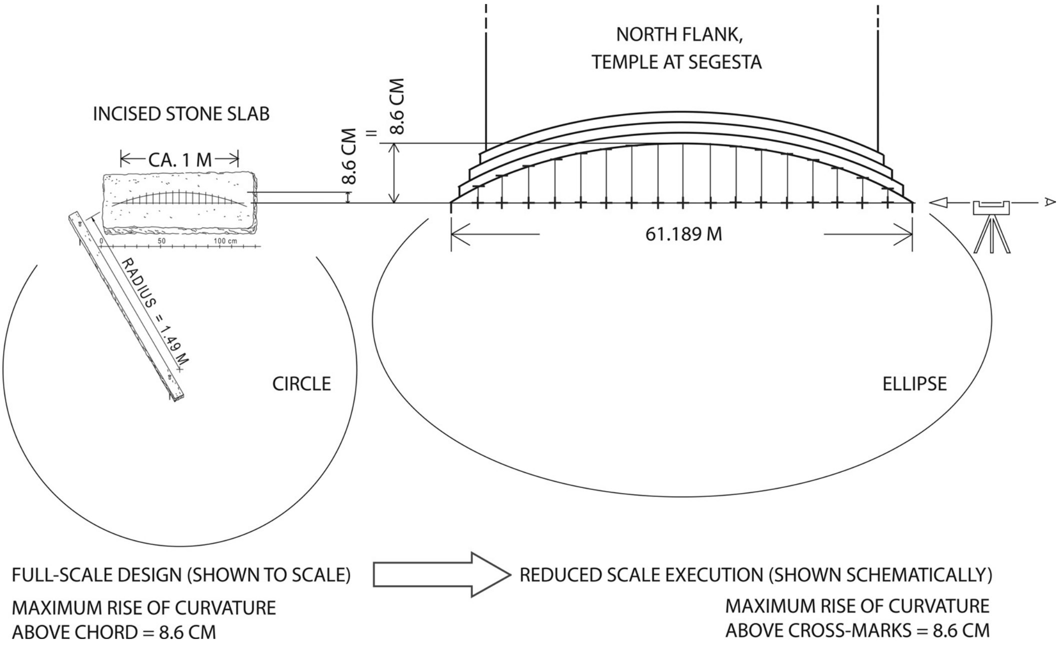
for this 1:16 scale is the relationship of the dactyl to the foot in ancient Greek metrology, wherein a foot is equal to sixteen dactyls (or "digits"). In the case of the drawing at Didyma, the foot measurement employed is an Attic (or Cycladic) foot of .296 m, with each dactyl measuring .0185 m.[9] The diagonal chord (*h*) flanking the arc (*g*) on the drawing's left side indicates a theoretical trajectory connecting outer radii of the lower and upper shafts were the column's profile straight instead of curved. To describe the curvature of the shaft's contour, midway up the shaft, an arc with a maximum rise of .0465 m above chord *h* (in mathematics called the sagitta) is created by a turn of a pair of dividers at a radius of approximately 3.2 m. Finally, the hatched horizontal lines in the drawing are set apart at distances of one dactyl (d1-d65) and correspond to distances of one foot in the elevation of the actual column of 18 m. Since the drawing maintains full scale in the horizontal direction, a pair of dividers can find the actual varying radius of the shaft at any given foot in its elevation. Based on the obtainable measurements, a second shaft was then drawn on the adyton's wall on its side in section at full scale in both width and height, again showing only the radius of the column from the central axis to the subtly curved outer profile.

The resulting entasis, therefore, is the product of a protraction along a single vertical axis, converting the circular arc to an elliptical arc that describes the shaft's curved profile in real dimensions.[10] The evidence preserved at Didyma may indicate a common procedure that may long antedate its employment there, possibly harking back to the same method of single-axis protraction in the design of columns in Classical buildings like the Parthenon.[11]

THE GRAPHIC BASIS OF HORIZONTAL CURVATURE

Haselberger theorizes precedents for Didyma's construction in the context of not only entasis, but also the design process of curvature that commonly began on the temple's platform, after which it was executed horizontally throughout the features of the superstructure. Along with entasis, this horizontal curvature had its beginnings in the Archaic period.[12] Also as in entasis, Vitruvius characterizes horizontal curvature as a response to the needs of vision by creating convexity through an addition intended to correct the eye's tendency to make large-scale horizontal features appear "hollowed" (3.4.5).[13] Primary evidence for the Didyma-related method for constructing curvature has been identified at the unfinished temple of the late fifth century in Segesta, whose design reflects influences taken from temple architecture in Athens.[14] Here, Dieter Mertens discovered a regular sequence of cross-shaped markings incised into the vertical planes of the euthynteria, all theoretically level and placed at equal distances.[15] These he connects with Vitruvius' *scamilli inpares*, a notoriously untranslatable term ("unequal ________") that, without elaboration, Vitruvius identifies as the element providing incremental curvature in the leveling of the stylobate (3.4.5, 5.9.4).[16] Mertens suggests that the *scamilli inpares* are the ordinates of the top of the euthynteria or stylobate that, in following a curved pattern with its maximum rise in the middle, are unequal with respect to the level sequence of cross-marks below. To establish these unequal ordinates, according to Mertens, the architect would have hung a string line end to end across the euthynteria, whose sag produced a nearly parabolic catenary.[17] Thanks to the well-preserved state of the north flank, Mertens was able to demonstrate this method's accuracy with great precision here by recreating the hypothetical string line.[18] In this way, the distance taken from each cross-mark to the level of the string would establish an equal distance to the ordinate marked above, providing the incremental curvature of the euthynteria as measured from point to point. Once the upper surface of the euthynteria was leveled according to these marked ordinates, the curvature was established for all subsequent courses in the superstructure.

Although this catenary method for near parabolic curvature is compelling, the discovery of the blueprint for entasis at Didyma provides a more likely


NORTH FLANK,
TEMPLE AT SEGESTA
INCISED STONE SLAB
CA. 1 M
8.6 CM
= 8.6 CM
0
50
100 cm
RADIUS = 1.49 M
61.189 M
CIRCLE
ELLIPSE
FULL-SCALE DESIGN (SHOWN TO SCALE)
REDUCED SCALE EXECUTION (SHOWN SCHEMATICALLY)
MAXIMUM RISE OF CURVATURE
ABOVE CHORD = 8.6 CM
MAXIMUM RISE OF CURVATURE
ABOVE CROSS-MARKS = 8.6 CM

61 Temple at Segesta. Illustration of the graphic procedure for platform curvature. Drawing author, adapted from L. Haselberger, in Haselberger and Seybold 1991: Figure 3.

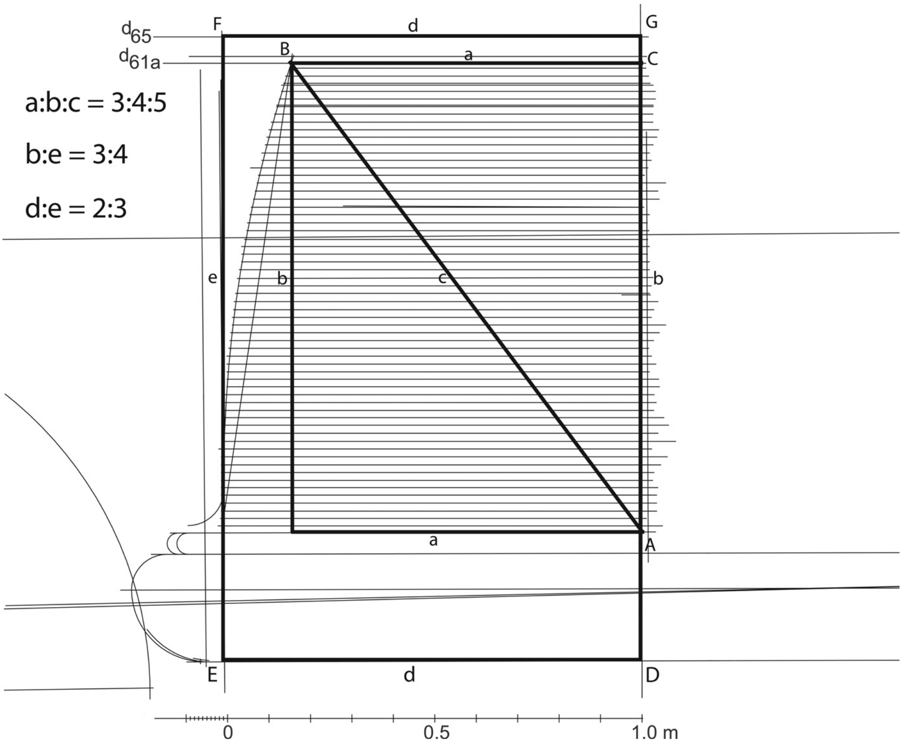
solution by way of a graphic construction for curvature. As demonstrated mathematically, the ordinates corresponding to the line-edge of euthynteria above the cross-marks along the well-preserved long north flank more accurately describe an ellipse than a parabola – a solution that also holds for the analysis of curvature in the north stylobate of the Parthenon.[19] Along with the mathematician Hans Seybold, Haselberger proposes instead that the cross-marks correspond to the divisions of a chord within the arc of a circle in a hypothetical working drawing akin to that found at Didyma (Figure 61).[20] As such, the interstices between the cross-marks protract those along the chord as baseline in the drawing, whereas the ordinates of the euthyteria's curvature simply transfer the drawing's measurements between chord and arc at 1:1 scale. This single-axis protraction therefore maintains an identical maximum rise (sagitta) in the drawing and euthynteria (.086 m) while stretching the drawing's circle into a theoretical ellipse that describes the temple's horizontal curvature. Based on the ordinates, the dimensions of the lost working drawing have been calculated: circle radius ca. 1.49 m, baseline (chord) ca. 1 m (Figure 61).[21] If along with Haselberger and others we may hypothesize that the architect at Segesta took this method from the Parthenon and other Athenian temples, then we can envision the possibility of reduced-scale architectural drawing at work in temples as early as the fifth century, at least of the single-axis variety.[22]

A NEW ANALYSIS OF THE WORKING DRAWINGS

In light of Chapter 1's difficulty in establishing either a philological or design-related justification for ichnography at work in Classical temples, the possibility of single-axis protraction as a common technique therefore carries important implications for the Greek principles underlying the graphic construction of large dimensions. Haselberger's study of the blueprint at Didyma and its larger relevance for curvature is thorough and impressive. In addition to the new avenues this research opens for questions of technical drawing and architectural design process, however, there is still more to be learned about the drawings themselves, including both the surviving drawing at Didyma and the hypothetical drawing for curvature at Segesta. The present study's analysis in Appendix A based on the Didyma construction and Seybold's calculations reveals potentially astonishing features never before observed in these drawings that may be of consequence for how one may understand the graphic basis of Greek building.

As Appendices A-B and additional considerations in this chapter show, in Greek temples the process of planning for curvature in columns (entasis) and across horizontal surfaces may have involved more than just simple additions or subtractions based on plain intuition. Rather, the analyses here suggest that the graphic procedures for optical refinements may have depended on the same application of whole numbers and modular commensuration characteristic of designing for individual elements and major dimensions in elevation and plan. Specifically, my analysis demonstrates that the blueprint for entasis at Didyma is itself constructed according to a geometric underpinning of a 3:4:5 Pythagorean triangle *ABC* with a module formed by the maximum rise of curvature, as well as meaningful whole number ratios shared throughout the drawing (Figure 62). Secondly, I demonstrate that the construction of the theoretical working drawing for Segesta's northern flank is an integral 2:3 ratio between chord and radius. Finally, I show how this procedure at Segesta may reflect an earlier application the same procedure carried out for the curvature of the flanks of the Parthenon, which, according to calculations, appears to have featured the same 2:3 ratio between chord and radius decades earlier (Figure 64). In shaping monumental form by way of single-axis protraction in this way, the Greek art of technical drawing appears to project whole numbers into buildings through a geometric transformation of conic sections (circle to ellipse).

In the manifestation of number in its built forms, the process of construction to be described here renders it beyond ready perception. Built into the world in such a manner, number and geometry exist in a way that is not visible but rather, from a Platonic perspective, only intelligible through measure. The process is like that of the divine craftsman of the *Timaeus*, who builds number into the world through the circular motions of the celestial bodies, which create



62 Hellenistic Didymaion. Restored blueprint for entasis with geometric underpinning indicated. Drawing author, modified from L. Haselberger, in Haselberger 1980: Figure 1.

the measures that shape a sense of order in space.[23] In visual experience in both built forms and the world described by Plato, the true numbers of the underlying (F)orms or *ideai* could be grasped fully if one had the chance to look upon (ἰδεῖν, βλέπειν, ἀποβλέπειν, κατιδεῖν) them directly.[24] Given this improbability, for Plato, visibly beautiful phenomena cause us to stop and allow their penetration into us through properly directed "upward" vision (*Republic* 490b, 527b, 529b), in which it is the perspectival "vision of the soul" (519b) that sees the Ideas, however incompletely. For this viewing, arithmetic (525c) and geometry (526e) prepare one more properly to see things, just as for Vitruvius, arithmetic and geometry (along with optics) prepare the architect to build them properly, particularly through the correct use of tools in technical drawing and construction (*De architectura* 1.1.4). As suggested in the present chapter's analyses of the evidence from Didyma and Segesta, drawing and construction in the aid of optical refinements do not just deceive the eye by additions and subtractions. More than this, they preserve the true character of number and geometry in a rationally protracted form.

For the purpose of reading Plato, it is perhaps more useful to focus on the role of measurement in the *process* of building rather than the outside observer's perspective of the completed work. In this light, it is interesting that Plato turns to figural sculpture rather than the art of building in his criticism of losing sight of "the true commensuration of beautiful forms" by not maintaining "the commensurations of the model" (*Sophist* 235d–e).[25] Among the arts, rather, Plato sets apart the building trade as deserving of special praise because its tools (compass, straightedge, set square, plumb line, and peg-and-cord) allow for such "scientific" (τεχνιχωτέραν) precision in its measurements (*Philebus* 56b-c). Bearing in mind the nature of the working drawings analyzed here, one may consider just what sort of measure guided builders in their application of such impressively accurate instruments. As Plato himself was certainly aware, they were guided by visions of whole-number relationships, commensuration, and "beautiful" geometry.

These guiding visions would have taken the form of the template (*anagrapheus*), model (*paradeigma*), 1:1 drawing (all three of these having planned individual elements at full scale), and reduced-scale drawing.[26] We have seen how Plato relies upon the metaphor of *paradeigmata* taken from craftsmanship. In addition, the description of reduced-scale drawing in Aristophanes' *Birds* reflects the existence of this technique of design in Athens in 414, establishing such *ideai* (to use Vitruvius' Greek term) as an available metaphor for Plato in Athens. Even though the philosophical use of these terms may originate in craftsmanship, they need not necessarily indicate any great interest in building on the part of Plato, despite his elevation of its status with respect to other arts.[27] Nor should one readily conclude that his contemplation of the specific processes of design and construction somehow led to the insights conveyed in his dialogues. Rather, we may limit our consideration to the qualities implicit in such elements that might have readily come to mind for Plato as an observant Athenian of the Classical period who admired the building trade's instruments and accuracy of measurement enough to mention such things, but whose aims were very different than those of an architect writing about his craft.

In light of the present chapter's analysis of the evidence concerning blueprints for entasis and curvature, the role of number in creating form deserves emphasis as a plausible accounting for Plato's interest in the accuracy of measurement enabled by builders' instruments of drawing and construction. The focus on integral ratios in these examples (Figures 62, 64) obviously recalls Pythagorean thought, but their process of design and building exhibits an application of number that stands somewhat apart from the Pythagorean spirit of numbers as concrete "unit-point-atoms."[28] Instead, the numbers exist beyond material form at the same time that the architect builds them into it, remaining quantitatively constant while qualitatively transformable in space through altered scale and shape. In single-axis protraction in particular, commensuration is maintained in a strictly abstract way that is concretely and visibly lost through the stretching of distinct proportional units along one dimension. The notion of the immutability of numbers, then, would be limited to their abstract ontological characterization as disembodied ideas separate from the built forms, though of course it is highly doubtful that any Greek architect ever would have thought about them in anything like such terms. Still, in a way similar to the respective measurements of intervals and time in music and astronomy that must ultimately relate to transcendent numbers and standards of beauty and goodness (*Republic* 530d–531c),[29] from a Platonic perspective, the craftsmen on the building site turn their eyes and tools toward the numbers set in a model. In turn, this model itself presents the work's idea in a graphic form that exists beyond the concrete, visible qualities of the work that it determines.

As discussed in Chapter 1, however, Plato complicates the metaphor both by conflating craftsmanship with the creation of cosmic order (Daidalos or a different craftsman or painter of *Republic* 529e, and later the divine craftsman of the *Timaeus*) and by introducing two kinds of *paradeigmata*: the secondary models of becoming, and the eternal models of being that generate these secondary models (*Timaeus* 27d–28a, 48e–49a). The status of Daidalos' "most beautiful" geometric drawings is thereby reduced to "admirable" rather than true in an absolute or autonomous sense. In this move, Plato subverts the very metaphor of craftsmanship that his discourse relies on, allowing his readers to redirect their focus toward a higher truth and beauty in the same way as a viewer of "real" geometry or astronomy may redirect his vision "upward" in the manner that one's soul should see. In this way, the metaphors of vision and craftsmanship unify through a reflection on the role of models in the creation of order.

CONSTRUCTING ENTASIS AT DIDYMA

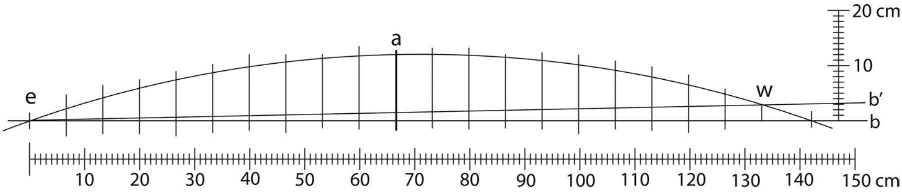
None of these claims related to Plato can stand without first demonstrating the existence of integral ratio and geometric form in the drawings themselves. As Appendix A demonstrates, the blueprint for entasis at Didyma is grounded in a 3:4:5 Pythagorean triangle *ABC*, itself embedded in a 2:3 rectangle (Figure 62). In addition to this geometric underpinning, the theoretical Pythagorean triangle is based on a modular conception, in which the arc's (g) maximum rise above the chord (h) creates the module that forms triangle *ABC* as a commensuration of 18:24:30. The relevance of the maximum rise of curvature as a distinct measure is reflected in Vitruvius, who prescribes that this *adiectio* should establish the breadth of the fillets in the column's fluting.[30] In remarkable way, therefore, the Didyma blueprint graphically constructs the subtle refinement of entasis according to geometric form, integral ratios, and modular commensuration. The effort required to work through all of these correspondences for the sake of a monumental final product in which these relationships would be visually lost renders it all the more interesting.

This procedure may suggest Pythagorean motivations for design like those explored in Chapter 1 and its supporting Excursus, but there is a more practical explanation, at least in part. The considerations underlying the process of design likely began with the architect's objective of column shafts of a height of 60 3/4 feet and a 9:1 ratio to their lower diameters (= ca. 18 and 2 m). Given this scale, he settled on approximately two and a half dactyls as an appropriate maximum rise of entasis. To construct a blueprint at 1:1 scale in its width, he would have had to construct and center a pair of colossal compasses of the right size specifically for this task (as in Figure 64). For the blueprint at Didyma, how would he have predicted the correct enormous radius of 3.2 m (!) and the location of its center without an inordinate amount of trial and error?

A likely solution is that the blueprint was itself worked through at reduced scale. In this way, the smaller plan's construction according to integral ratios would lend itself to easy transfer onto the surface of the adyton's wall. At small scale, the architect could manipulate regular-sized instruments and sketch his way through various versions required to get the desired relationships of parts.[31] Accordingly, he could begin by constructing Pythagorean triangle *ABC*. The purpose of this form would not be mystical, but rather to control the orthogonal relationships throughout the drawing, ensured by the whole number measurement of the hypotenuse; in a Pythagorean triangle, integral ratios between the sides and hypotenuse establish a perfect right triangle, and therefore perpendicularity. Experiment with a pair of compasses would find the center point for a radius able to produce an arc with a maximum rise equal to one part of any side of triangle *ABC* over a chord drawn to *B*. Based on these measurements, all of these details could be converted arithmetically to the final dimensions of both the large compass specially made for the occasion and the blueprint whose curvature it constructs. If the plausibility of this conjecture is accepted, one may consider that the practices of 1) single-axis protraction represented by the blueprint and 2) full protraction indicated by blueprint's generation from the hypothetical plan that preceded it existed side by side by the middle of the third century.

SEGESTA AND THE PARTHENON

To return to the fifth century, there is a new observation to be made concerning Haselberger and Seybold's hypothetical working drawing for horizontal curvature at Segesta (Figure 61). As shown in Appendix B in this book, this drawing's chord shares an integral 2:3 relationship with the radius of the arc. Rather than requiring a reduced-scale version of the drawing in the manner proposed here for Didyma, the architect appears to have simply begun with a 2:3 ratio in mind, constructing this relationship as a chord and circle with a length and radius of eighteen and twenty-seven modules, respectively.



(20 divisions hypothetical)
a = axis
b = baseline
b′ = baseline adjusted for uneven levels
e = easternmost end
w = westernmost end

63 Parthenon, Athens. Restored chord and arc of the construction for platform curvature in the north flank, according to Seybold's calculations. Drawing author.

Despite this difference, the hypothetical construction for curvature at Segesta betrays an unmistakable kinship with the qualities of the blueprint at Didyma, as revealed in the present study. In both examples, whole numbers as applied to compass-and-straightedge construction drive the design process of features meant to be intuited visually rather than intelligibly through numerically or geometrically based contemplation. In the case of the hypothetical drawing at Segesta, moreover, the 2:3 ratio and relationship of eighteen and twenty-seven modules anticipates a wide-scale application of dimensions based on proportions divisible by two and three throughout the elevation (Figure 17), as in the 2:3 relationship between triglyph and metope widths as well as the column axes and entablature height, and the 9:4 relationship in the principal rectangle and the column spacing and height of the steps. In plan, furthermore, there is another 9:4 ratio in the relationship of the stylobate's length and breadth.[32] In a peculiar way, therefore, the evidence at Didyma and Segesta may suggest that the creation of subtle visual refinements in temple buildings through reduced-scale drawing is driven by a similarly schematic approach to that found in the relationships of individual features and broad dimensions.

Perhaps most remarkably, evidence for this same procedure may be seen at the celebrated Parthenon itself. As demonstrated in the analysis in Appendix C, the relatively well-preserved long north flank of the stylobate allows for an interesting, mathematically grounded finding concerning the graphic method for constructing the Parthenon's curvature. As one finds for the proposed theoretical working drawing for curvature in the flanks at Segesta (Figure 61), the chord in the theoretical drawing required to produce the curvature of Parthenon's flanks features an integral 2:3 ratio with the arc's radius (Figures 63, 64).

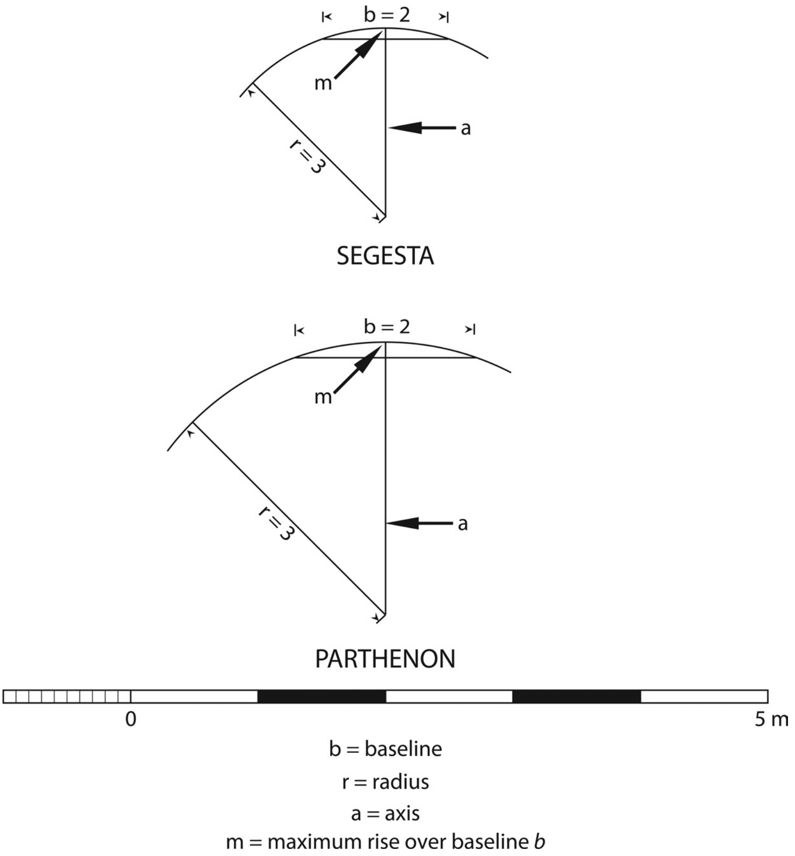
Whatever the similarities observed in the theoretical blueprints at Segesta and the Parthenon, it is important to stress that the analysis here proves nothing. Rather, it simply works with Seybold's calculations in conjunction with the data taken from a sample of field measurements and other archaeological considerations from an identical context (flank curvature) in the temple at Segesta and the Parthenon. The identical 2:3 ratios for the same theoretical construction in both cases could be entirely coincidental, and unless additional future evidence emerges, one would do best to remain circumspect about this consistency isolated to Segesta and the Parthenon. It must also be emphasized that the result found here for the Parthenon depends on a reading of the differing levels as intentional, which should not necessarily be the case.

On the other hand, the identical result returned for both instances is arguably interesting, establishing a potential plausibility of the 2:3 ratio in each case. The suggestion of a pattern may also support Haselberger's conjecture that the Didyma construction for entasis may have been employed at Segesta, the Parthenon, and perhaps other temples. Finally, whereas one may view the dependence of the present analysis on the notion of the Parthenon's "hyper-refinements" as a weakness, in a more positive way one may conversely view the result of this approach as support for the rises as indeed intended. In summary, the present reading of Seybold's calculations and geometric analysis may offer new inconclusive considerations to our continued (and perhaps interminable) discussion of how ancient Greek architects may have designed curvature.

When put to a simple mathematical test, then, the evidence of the Parthenon may thereby support Haselberger's "Didyma conjecture" in the design process for curvature at Segesta. Like the latter's other features reflecting Attic influences,[33] it would make sense that its method for establishing curvature was taken from practices already established in an Athenian antecedent like the Parthenon. The tentative suggestion of this analysis that the Parthenon may have employed the same method and even the identical whole-number ratio as the temple at Segesta also renders the theory of intentional "refinements of refinements" (rather than errors in leveling) in the Parthenon yet more compelling. More important for the present study, in these two temples for which data are available, calculations offer some support for the proposed practice of single-axis protraction for curvature. In the northern flanks at both Segesta and the Parthenon, conceivably, scale drawing exists by way of the architect's application of the numbers two and three to a chord and radius, and the extension of the divisions of the chord into segments corresponding to dimensions in real space.

SINGLE-AXIS PROTRACTION RECONSIDERED

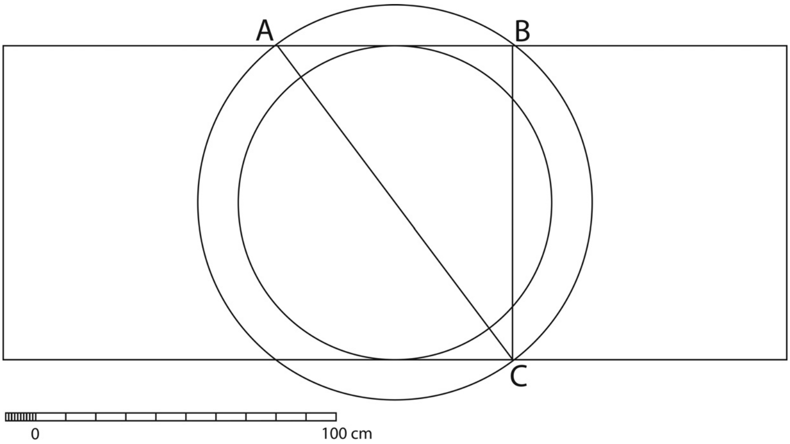
Regardless of when and where single-axis and full-fledged scale drawing were invented, the means by which architects imparted a sense of order seems to have been continuous with practices found in traditional design. As a case in point, Gruben shows that in the capitals of the Archaic precursor to the Hellenistic



64 Proposed graphic constructions for platform curvature on the northern flanks of the temple at Segesta and the Parthenon. Drawing author.

Didymaion, a 3:4:5 Pythagorean triangle *ABC* established both the width of the volutes and the diameter of the upper column shaft according to an integral 4:5 ratio with the diameter of the echinus (Figure 65).[34] In the construction of entasis by way of single-axis protraction in the Hellenistic Didymaion, the same geometric underpinning returns. During the following century in Temple A of the Asklepieion at Kos, the application of the Pythagorean triangle is found yet again as an organizing principle in the art of ichnography (Figure 86).[35] What this continuity may begin to suggest is that the origins of the *ideai* in the sense of reduced-scale drawings shaping spatial relationships may be closely tied to age-old ways of constructing order in individual masses. Yet despite the survival of such tradition, the transition from a geometric underpinning that shapes tangible, plastic features to an invisible linear network ordering relationships across voids from an aerial perspective represents a significant intellectual shift deserving further explanation throughout the present chapter.

First, one may underscore the relationship between number and built form through the application and manipulation of geometric form. In Chapter 1 and

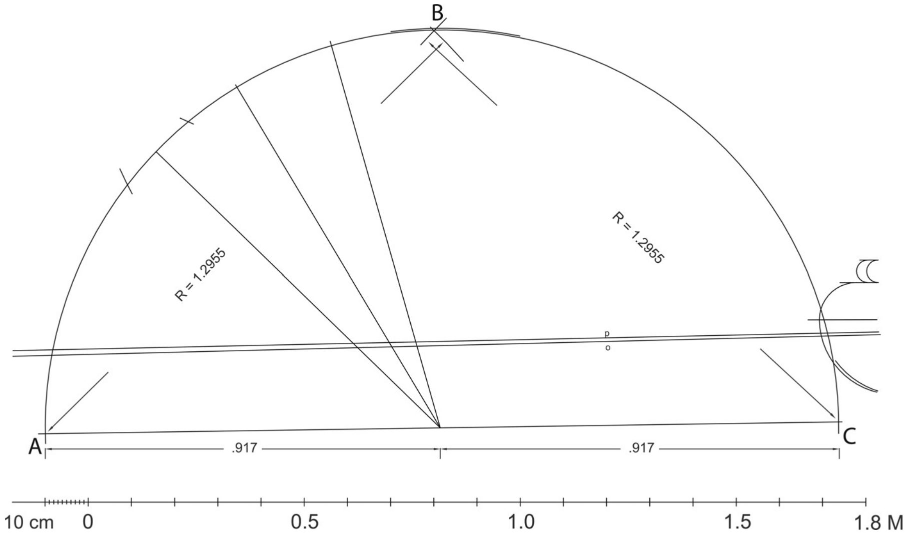


65 Archaic Didymaion, sixth century B.C. Restored capital shown by G. Gruben to have been designed according to Pythagorean triangle *ABC*. Drawing author, modified from G. Gruben, in Gruben 1963: 126. Drawing author.

its supporting Excursus, it is observed how, as a text with Pythagorean overtones that may reflect architectural theory, the *Canon* of Polykleitos appears to have connected beauty with commensuration,[36] and that whole numbers bring forth "the good" through what seems to have been intuitive adjustments to those numbers.[37] This background gives rise to the possibility that optical refinements as departures from "true" numbers and straightness are integral to the beauty and goodness of buildings. On a related note, the Excursus also observes Aristotle's emphasis on the value of chance in the art of building (*Nicomachean Ethics* 6.4). Although it is unclear whether this value is applicable to optical refinements in monumental temples, in one possible reading, Aristotle's statement seems consistent with the connection between intuitive judgment and good results. On the other hand, the role of intuition and chance in building specifically may pertain simply to the effectiveness of the adjustments planned beforehand, which cannot truly be known until one views it in the dimensions of the completed form.

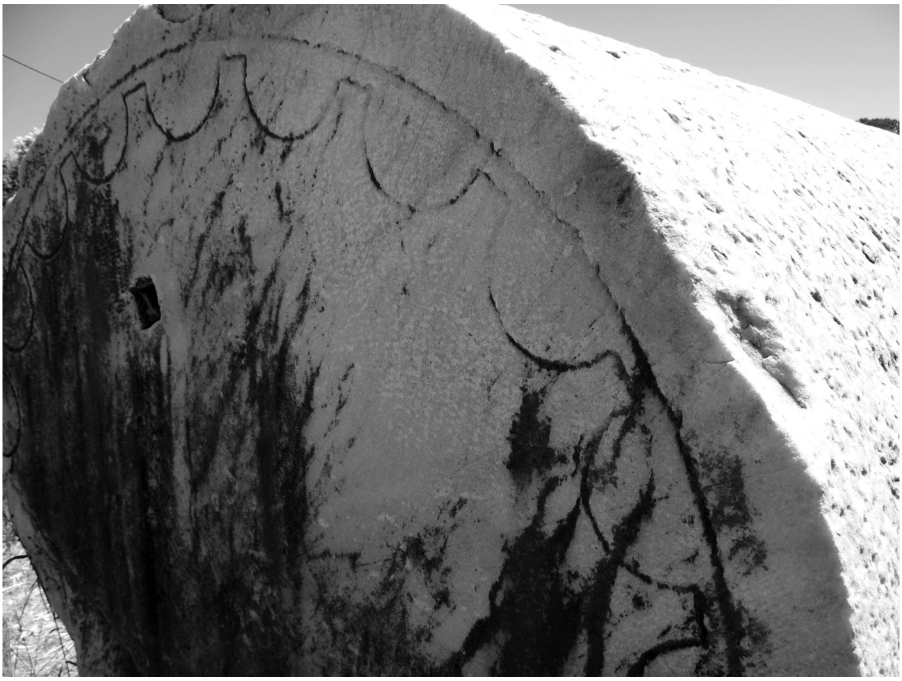
Radial Protraction

Beside and partially intersecting the Didymaion's blueprint for entasis is a large semicircle with radial divisions creating two wedge-shaped sections each equal to one-twelfth of the semicircle (Figure 66).[38] The obvious purpose of this drawing is to establish the equal divisions of the column shaft's perimeter for the twenty-four flutes and arrises of the Ionic order, although the details of how this procedure works require some explanation. In general, though, the blueprint illustrates how a Greek architect might have conceived of the fluting of columns as a radial construction from the center point of a circle.



66 Hellenistic Didymaion. Restored blueprint for column fluting (see Figure 33). Drawing author, modified from L. Haselberger, in Haselberger 1980: Figure 1.

The drawing at Didyma compares with other known material. An Ionic capital from Pergamon in the museum at Bergama preserves the radial lines that positioned its arrises,[39] and there is a Doric capital that shows the same method at work.[40] Drums for the Hellenistic stoa in the agora at Kos again preserve the radial construction for the fluting of its Ionic columns (Figure 67), in this case revealing the graphic arcs of the flutes before carving.[41] Such a procedure compares with the work of modern restorers who create new drums for the re-erection of columns, or who restore drums based on surviving fragments.[42] The method relies on the flat plane of the drum or capital neck in order to create the fluting, which is different than the procedure that appears to have been applied in the unfinished Roman columns at the western front of the Artemision at Sardis, for example, where the flutes were begun but never completed (Figure 68). Here, one of the two fully standing columns erected in the second century A.D. terminates the extent of its flutes above the bottom of the capital (certainly a technique aimed at avoiding damage to the delicate arrises during placement on the erected column), suggesting that the divisions were marked on the curved surface of the neck's profile.[43] Indeed, as the temple's current investigator Fikret Yegül has pointed out to me on site, finely incised vertical lines run down the length of the shafts, possibly tracing plumb lines dropped from above that established the fluting at the top as well as their intended continuation toward the base. An unfinished column on the porch of the Didymaion preserves similar lines incised around the perimeter of its lower shaft as well, in this case clearly marking out the arrises. Still, the use of such plumb lines would not preclude a radial construction on the flat plane of the uppermost drum, which may have



67 Stoa, Agora, Kos. Unfinished Ionic column drum preserving the radial construction for the fluting of its Ionic columns. Photo author.

determined the hanging points in a manner to be described later. But what separates the drawing at Didyma from each of these examples is its function as a *model* for columns yet to be designed, rather than a guiding procedure worked through on the columns themselves.[44]

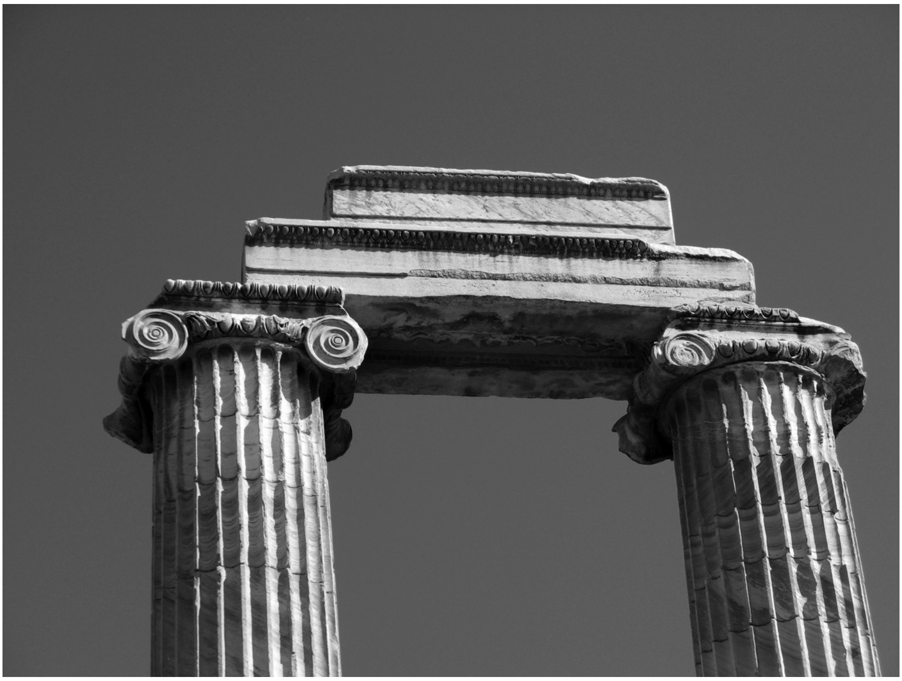
In general, the relationship between segments along a circular perimeter and radial lines converging on a central point was undoubtedly obvious and quite old, observable in everyday activities like the slicing of round loaves of bread. In the art of building specifically, the molded and painted surface patterns around concentric circles on works like the monumental terracotta discoid acroteria from the Heraion at Olympia of ca. 600 demonstrate that the interest in such patterns was quite ancient.[45] In the earliest traditions of Hellenic building, felled trees used as columns in timber construction (and the trunks left behind) would have preserved vascular rays radiating out from a natural center point (the pith), possibly suggesting a similar form for the tops of columns in the same way that naturally vertical striations of the curved surface might have suggested the idea of flutes running down a shaft. As observable in buildings of timber construction or modern telephone poles, these vertical striations are, in fact, the same vascular rays that appear in a radial form when viewed on the surface above and below, and it is conceivable that the beginnings of column fluting may have owed something to the imitation and regularization of this natural linear

68 Artemision, Sardis. Detail of column. Photo author.

correspondence in timber antecedents. Regardless of this question of origins, however, regularized precision characterizes fluting in surviving columns like those at Didyma. Without the accuracy of an angular measurement of 15 degrees for each of the twenty-four divisions of a drum as established in the blueprint, the columns would appear faulty no matter how much care went into their execution.

How this precision was achieved is unknown. Vitruvius, who is clear that Ionic shafts require twenty-four equal flutes (*De architectura* 3.5.14), leaves aside how the method is to be executed.[46] One hypothesis stresses that there need not be a theory underlying the method, and that the task may instead depend upon on a certain amount of "fudging" with a pair of dividers progressively adjusted through trial and error.[47] A second possibility considered here is that by the Classical period, architects were masters in working with the instruments and methods of technical drawing. In this view, the notion that these architects would have fudged their way through graphic constructions for something so common as fluting by mere trial and error either confuses their knowledge for our own unfamiliarity with their tools and procedures, or unduly discredits the amount of acquired experience gained in working with such tools since the earliest days of Hellenic building.

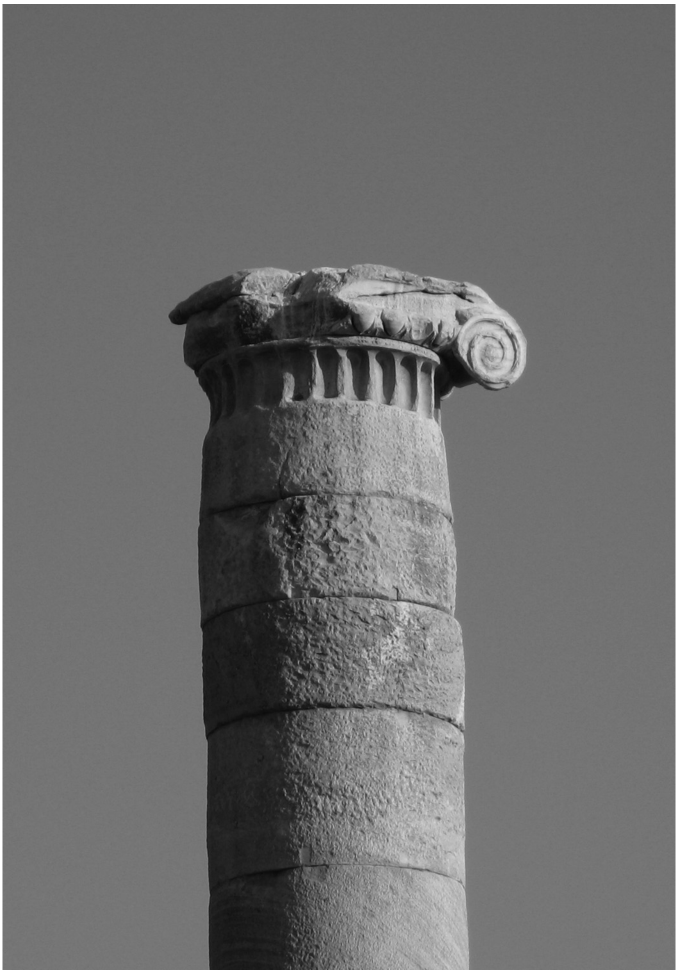
At least hypothetically, the fluting on the colossal columns at Didyma (Figures 69, 70) may be understood as a product of an intended construction process aided by the blueprint for fluting preserved on the wall of the adyton (Figures 66, 73). That it was drawn with a radius larger than that of the necks



69 Hellenistic Didymaion. Detail of standing columns on northeast flank. Photo author.

of the columns ensured its application for necks of slightly varying widths due to the varying heights of column drums, a concern perhaps also reflected in the larger circumference drawn around the markings for arrises in the column at Kos (Figure 67). Using calipers, the stonemason may thereby transfer the entire blueprint to his block of marble, including its radial lines connecting the perimeter with the center (Figure 71.1). This guiding drawing could be placed on what would become either the upper surface or the underside of the drum. In the latter case, within its radius the mason may then draw the smaller radius of his column drum, whose intersections with the radial line can establish the width of the flutes to be repeated around his circumference with a pair of dividers (Figure 71.2). Centering his dividers at each marked point, small uniform arcs establish the flutes and arrises (Figure 71.3). After the column drum is carved down to the curved surface established by the smaller radius, the fluting could be carved from the underside of the drum up toward its lip (Figure 70), serving as a guide for the carving of the flutes down the entirety of the shaft (Figure 59).

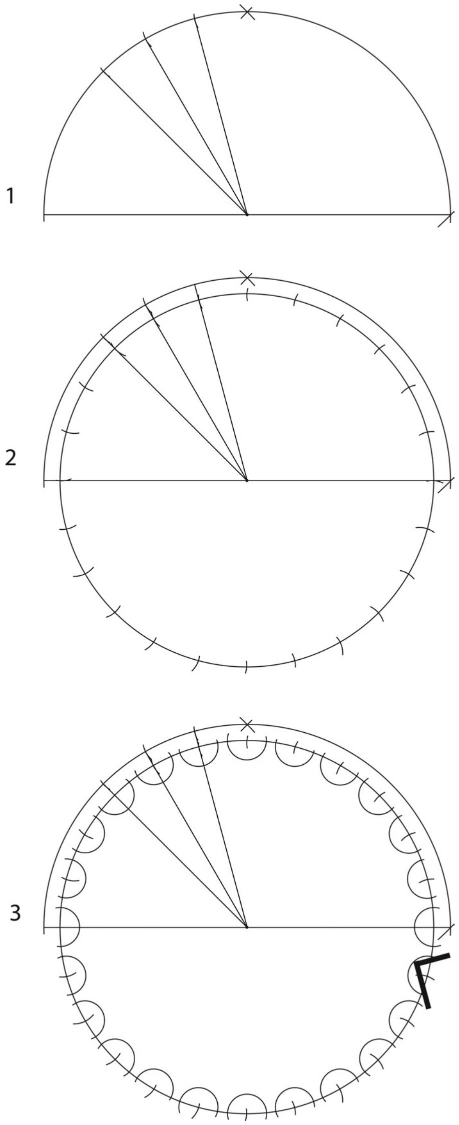
This explanation still does not account for how the architect created the radial divisions of 15 degrees in the blueprint that serve this process. A likely method would be to follow the same algorithm of circumferential intersections found in the six-petal rosette (Figures 42). To do so, the architect would begin by quartering the circle with the intersection of two arcs at the top of his drawing



70 Hellenistic Didymaion. Detail of standing column on southeast flank. Photo author.

formed by a pair of compasses centered on either end of the baseline (Figure 72). Next he would mark a segment that, from the top of the arc, is one-sixth of the semicircle and then bisecting it with a pair of dividers (Figure 72). Alternatively, after quartering the circle, the architect may have used a tool akin to the "curved ruler" described by Aristophanes (Figure 74), which would have allowed him simply to lay a straightedge over the curved ruler's guiding radii and then, in order to set the straightedge flush against the plane, remove the curved ruler before incising the blueprint's radii from the perimeter to the center (the lines of the drawings radii continue past the center points – see Figure 73).

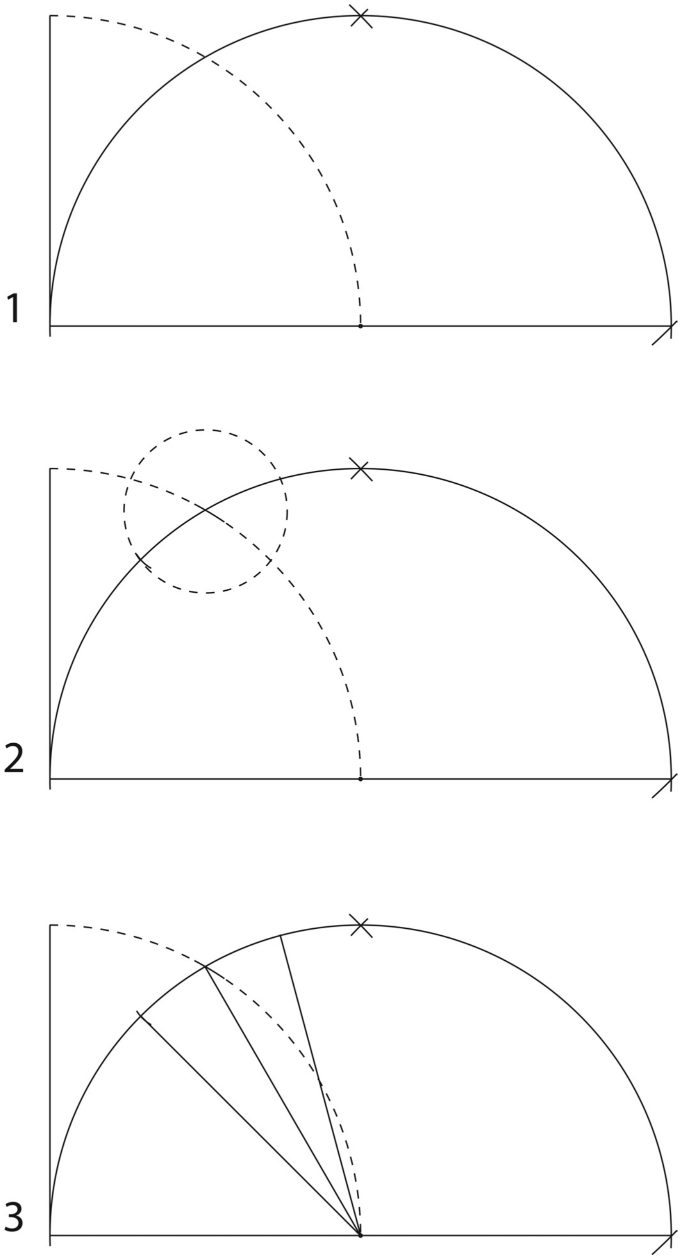
The ease of applying either the rosette method or the curved ruler raises the question as to why the stonemasons could not simply have executed the fluting without the aid of an architect's blueprint. Indeed, one may well ask whether such skilled craftsmen ever bothered to follow the provided model. Purely



71 Proposed sequence of for fluting drums at the Hellenistic Didymaion according to analysis of blueprint. Drawing author.

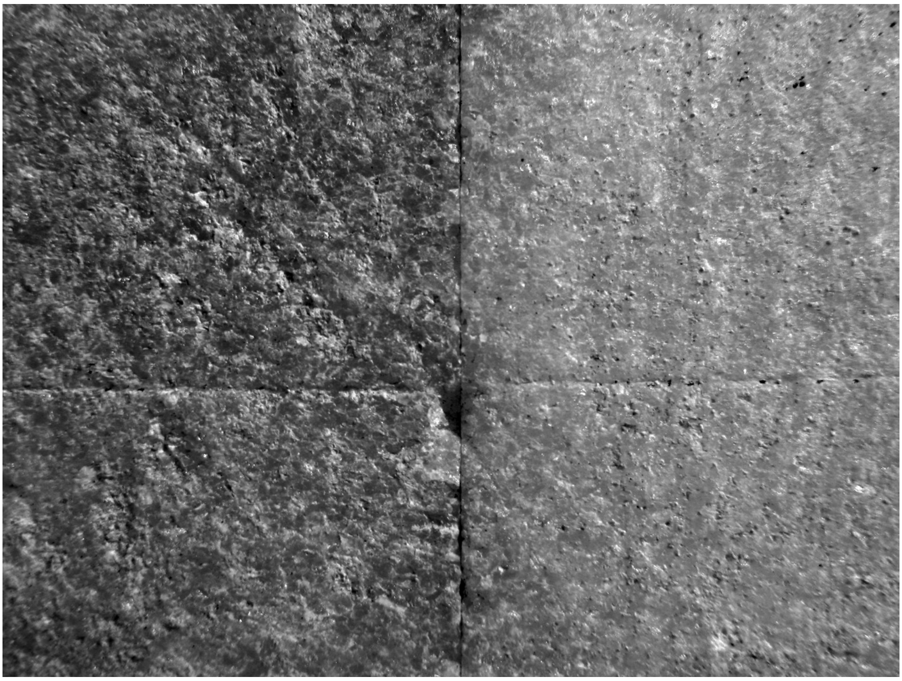
didactic motivations for the blueprint on the part of the architect must not be ruled out. As anyone who has mastered certain tools knows, artistry need not depend on diagrammed procedures. Likewise, one may question the practical as opposed to theoretical value of the neighboring blueprint for entasis analyzed earlier – a possibility that should in no way limit its value for our knowledge of the Hellenistic architects' understanding of the design process.

In the case of the Doric order, an architect or mason divides the perimeter of his drums into twenty segments of 18 degrees rather than the twenty-four segments of 15 degrees required for Ionic fluting.[48] Again, Vitruvius does not specify how this construction is to be achieved. One proposed procedure to be

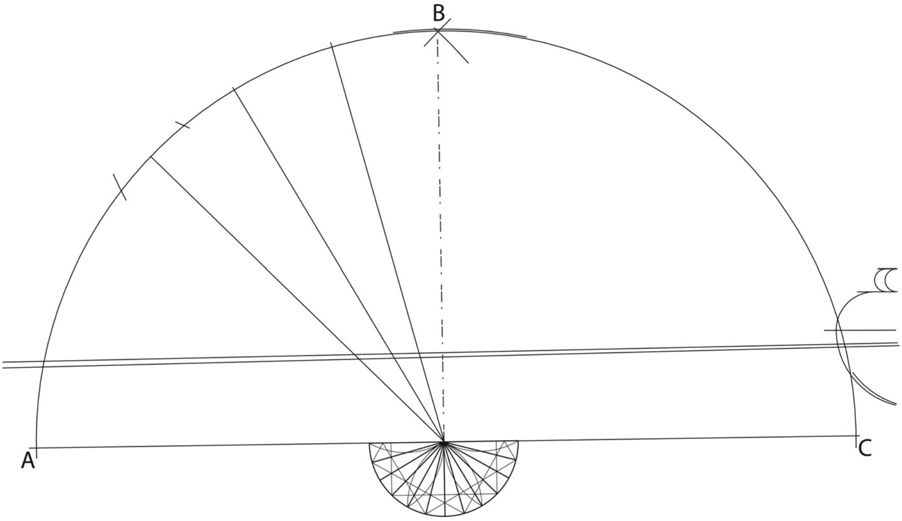


72 “Rosette-based” method for determining fluting on a blueprint like that at Didyma. Drawing author.

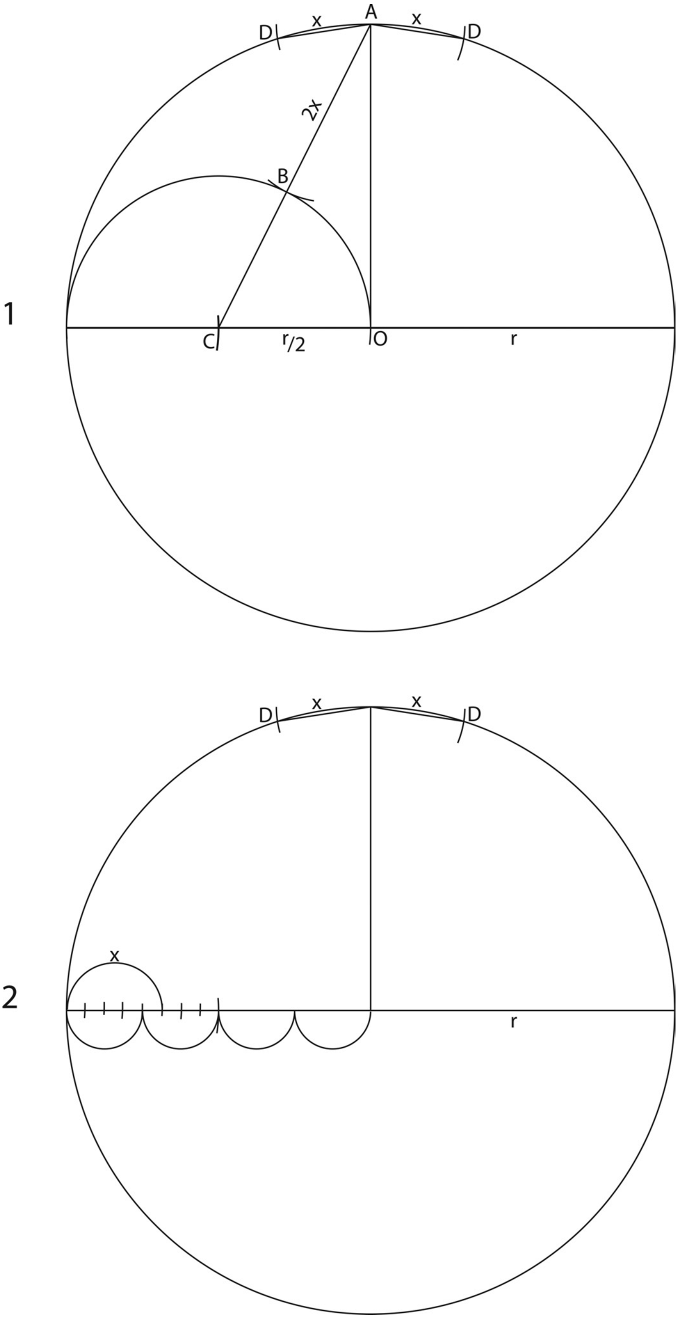
set aside is the establishment of the twenty equal segments as half the distance of the diagonal from a circle’s apex to an arc of a diameter equal to the circle’s radius (Figure 75.1).[49] Quite simply, a geometric analysis of this procedure demonstrates too high a tolerance for the precision that fluting requires.[50]



73 Hellenistic Didymaion. Pit on surface of the north adyton wall of the Didymaion, marking the point of convergence of radial lines and the center point for the large semicircular arc of the blueprint for column fluting. Photo author.



74 Hellenistic Didymaion. Restored blueprint for column fluting at Didyma, showing hypothetical placement of protractor proposed for the construction of the radial lines for the twenty-four divisions of the perimeter. Drawing author, modified from L. Haselberger, in Haselberger 1980: Figure 1.


D
x
A
x
D
2x
B
1
C
r/2
O
r
D
x
x
D
x
2
r

75 Hypothetical methods of producing twenty equal divisions of circumference for Doric fluting, proposed by P. Gros (top) and J. Ito (bottom). Drawing author.

A more plausible solution is the division of the circumference into segments each equal to five-sixteenths of the radius, resulting in a demonstrable degree of precision (Figure 75.2).[51] Perhaps the only serious drawback to this second proposed method would be its complexity. Given the inevitable slight variations in radii on the flat surfaces of individual drums, it would be cumbersome to work out five-sixteenths of a radius each time with a pair of dividers. Each radius would need to be quartered, and two of these quartered sections quartered again to find five fourths.

I know of no discoveries of markings on drum surfaces resembling this construction, but there is reason to suppose that a method at least related to this technique was employed. As previously mentioned, the Ionic columns of the stoa in the agora at Kos (Figure 67) preserve an incised radial construction akin to that of the blueprint at Didyma, and the underside of a Doric capital at Pergamon demonstrates the conception of Doric fluting as a centrifugal arrangement radiating from the center of a circle.[52] Whether the construction in question involves twenty-four or twenty segments, these drawings obviously describe a radial protraction of equal angular divisions ready to be applied to perimeters of variable sizes. Equally obvious, the instrument that would facilitate this radial protraction is the curved ruler mentioned by Aristophanes. As opposed to the rosette-based method of equal intersecting circumferences that could easily construct the radial divisions of the curved ruler to be used in the Ionic order, an architect could construct the ten divisions required of a semicircular ruler for Doric fluting through the method of finding five-sixteenths of this semicircle's radius and connecting the resulting divisions on the tool's perimeter with its center.[53] As products of the compass and straightedge, then, these curved rulers would have been extensions of these generating tools, and thereby part of a standard apparatus for designing columns based on the principle of radial protraction.

The method suggested here in accordance with the blueprint at Didyma would describe only one of many possible ways that Greek architects and masons would have fluted drums. Undoubtedly, several means were employed in the many building projects throughout the Greek world over the centuries. The dearth of evidence of the kind scantly preserved at Didyma, Pergamon, and Kos prevents us from proposing anything like a universally applied procedure for column fluting in antiquity.

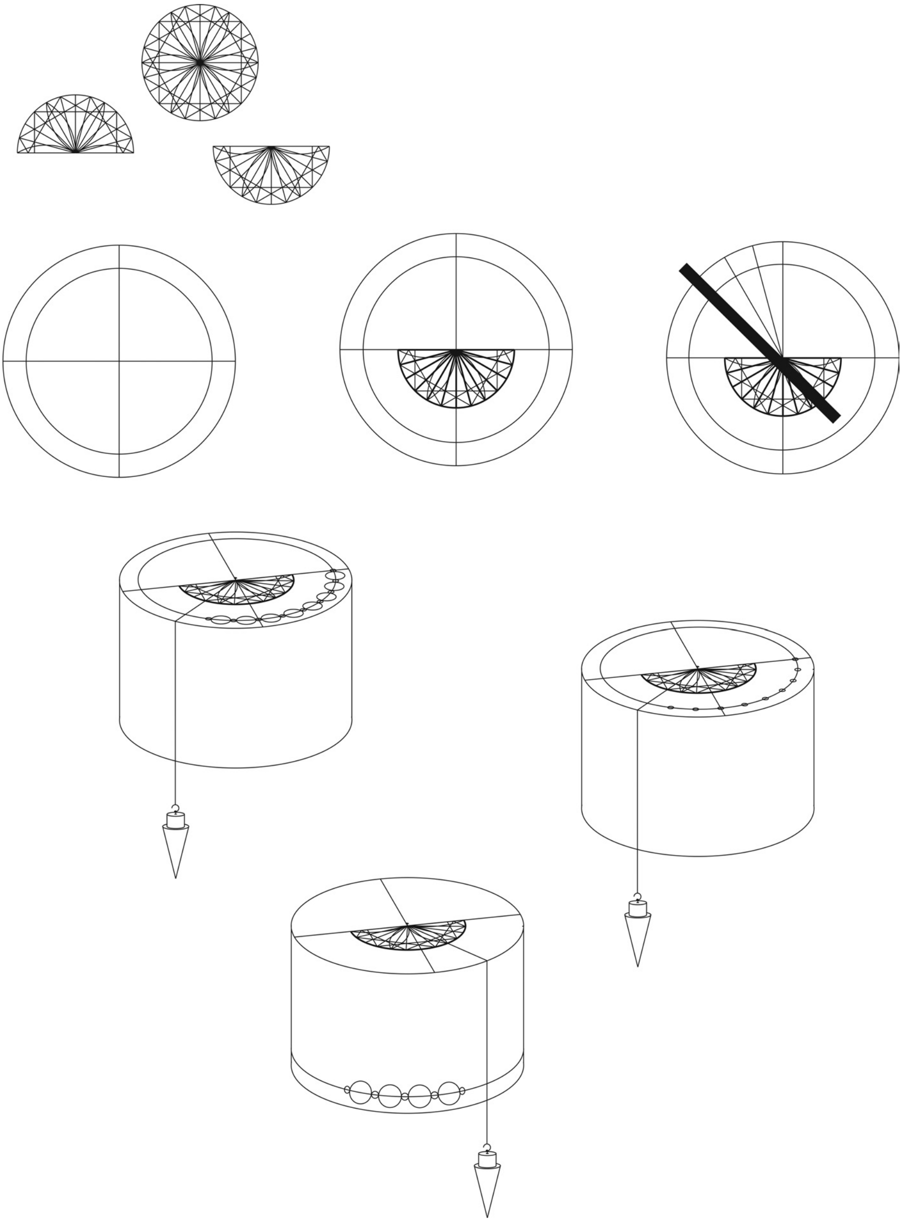
On the other hand, it would be ill advised to equate the limited explicit evidence with anything resembling the frequency with which the proposed technique would have been applied. In the first place, the fortunate survival of the blueprints at Didyma due to the colossal sanctuary's unfinished state certainly suggests the existence of similar on-site graphic models that do not survive. Haselberger's "Didyma conjecture" discussed earlier suggests this very possibility, in which the same construction for entasis may have been employed in designing curvature in temple platforms as early as the fifth century, as in the unfinished temple at Segesta and the Parthenon. In addition, the repeated 2:3 ratio of radii in the hypothetical working drawings for curvature in these temples observed here offers further support for the commonality of such constructions, and it is only logical that the same level of commonality proposed for single-axis protraction may extend to constructions for radial protraction as well.

Secondly, side by side with the question of models like the blueprint for fluting at Didyma, the indication of radial protraction in the shafts at Kos and capital at Pergamon suggests the existence of a *direct* application of the technique without dependence on a model. In other words, even though the architect may supply a model for obtaining the measurements of flutes for drums of varying diameters as in the case at Didyma, the surviving traces on these other members may demonstrate that, in some cases, craftsmen would simply apply a protractor themselves. In such cases, the effort taken to incise the radial divisions extending from the curved ruler would represent only one, perhaps excessively laborious way to use this tool. Arguably, a better method than incising along a straightedge from the curved ruler would be the use of a plumb line in conjunction with the curved ruler, which would allow the craftsman to establish the markings for flutings alternatively at the top, the edge, or the curved outer surface of the drum (Figure 76) or capital. Feasibly, this method could have been applied to the surviving unfinished drums of the Archaic Parthenon, which preserve the initial fluting ready to be continued upward to the necks of the capitals (Figure 25). As seen in the long incised lines running down the columns at Sardis mentioned earlier, if combined with a protractor, the plumb line could even provide an additional control for the extension of flutes running all the way down the shafts. The plumb bob would interfere with the line's adherence to the shaft's surface, but this problem would be solved without difficulty by applying manual pressure to the line in a way that would not affect the line's true verticality. In most cases, however, the use of a curved ruler, plumb line, and pair of compasses need not have left any trace of facture beyond the fluting itself. There is therefore a number of ways to have used the curved ruler known by Aristophanes, combined with the compass, straightedge, and plumb line. Nor should one discount the degree to which multiple tools and procedures would have been used together as a means of ensuring a number of controls for the sake of exactness and conformity, including the direct application of the curved ruler even when provided with an architect's blueprint in the manner seen at Didyma. Indeed, it is the full array of available tools allowing the craft of building to achieve its high level of precision that seems to have impressed Plato as the highest of the *technai* (*Philebus* 56b-c).

Before ending this brief introduction to the instruments and methods of radial protraction in the design of column fluting, a tentative and unprovable conjecture concerning its relationship to single-axis protraction may be valuable. Despite the clear evidence for single-axis protraction provided by the blueprint of the third century at Didyma (Figure 66), in their earliest Archaic manifestations, entasis and platform curvature might have been born of the catenary and other possible methods.[54] Regardless of the variety of ways to achieve a similar result, Seybold's calculations and, to a lesser degree, the observation of whole-number correspondences discussed in the present chapter support the plausibility that single-axis protraction was one of the methods that architects employed as early as the fifth century. Yet with respect to something like hanging a rope in the catenary method, the technique of extension through metric adjustment along a single direction is so abstract as to make one wonder how anybody could have come up with such a concept.

One possibility worth considering is that the method may have been suggested by the habits of working through graphic constructions for fluting. In addition to the protractor-based method, the related rosette-based method of intersecting circumferences applied directly to the perimeter of a blueprint or Ionic drum surface produced a many-sided polygon. With or without a protractor, an architect's observation that the same technique of circumferential intersections produced an equal amount of segments irrespective of a drum's size would have suggested the very concept of reduced-scale drawing: The process of drawing at a relatively smaller scale anticipates an identical form at a larger scale. Again with or without a protractor, the principle that unites the smaller and larger forms is that of equal angular divisions in a polyaxial arrangement converging on and emerging from the center of a circle, which describes the principle of radial protraction itself. Based on these radial axes, the result is a polygon of twenty-four chords, with the presence of these chords perhaps more pronounced when interconnected, as in the related construction of the zodiac (Figure 77).

The blueprint for entasis and the related hypothetical drawings for platform curvature are simply constructions of these same basic elements of axis, chord, and circle or arc, with the difference being an abstractly produced protraction along a *single* axis rather than along *all* axes. It would make sense that, in order to grasp this principle of protraction, one would first have to see it at work in radial protraction where it is indeed visible rather than merely intelligible. In constructing fluting at 1:1 scale for drums of different sizes, the experience of working with and developing tools and techniques would allow architects to see the relationship between the resulting product of the fluted shafts and the universally applicable geometric form that underlies all such shafts despite the individual variations between them. Once the underlying form exists separately as a concept in the architect's mind or on his drawing surface, he can transform it abstractly through measurement and the imagination. In this way, the whole



76 Hypothetical methods of fluting columns using a protractor. Drawing author.

numbers defining the circumference according to radial divisions converging at a center point are displaced by whole numbers defining the radius, chord, and other dimensions through linear rather than angular measurement. Yet it was perhaps the integral commensurations of the curved perimeter, born of angular relationships and defined visually as concrete units of flute and fillet, which were among the earliest modules of classical architecture.[55] Later applied along straight lines in constructions for single-axis protraction (Figure 61) and, as we will see, across space according to the full potential of radial protraction, the module as an anchor for the principle of commensuration ultimately may have originated along with the tools and techniques of 1:1 scale drawing for the fluting of columns.

LINEAR PERSPECTIVE AND THE BIRTH OF ARCHITECTURE

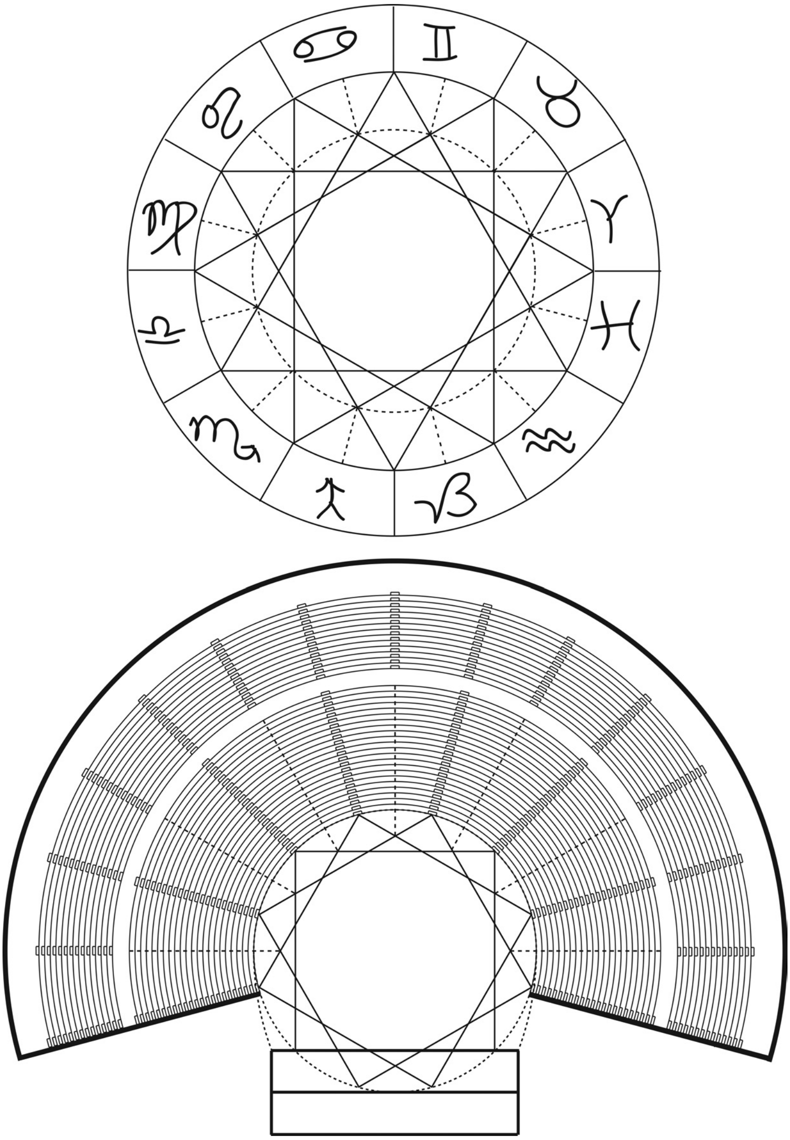
As discussed in Chapter 2, Meton's geometric form in *Birds* describes no city existing outside the fictional dialogue of Aristophanes and makes more sense as an allusion to the circular, radial form of the theater itself in which Meton delivers his lines. Again, theaters traditionally were *not* circular and radial, with the first non-timber example being the Theater of Dionysos whose rebuilding in stone began in ca. 370. Either Aristophanes' lines of 414 anticipate the later form or, more plausibly, the form of the stone theater gave permanent expression to the experimental circular, radial composition of its earlier phase. As such, the theater that Aristophanes refers to in order to connect with the experience of his audience was itself influential for the subsequent reshaping of the Pnyx according to a circular arrangement at the close of the fifth century.

In connection with this process of fluting column drums described previously, it is again worth quoting Meton's brief description of his *idea* for a city of the birds in the farcical dialogue of Aristophanes:

> From up here I set down this ruler, which is
>
> curved, insert a pair of compasses . . . and lay down a straight ruler and extend it across to make a circle quartered with an agora in the center, and so just like we have with a star – itself being circular – rays will beam out straight all around. (999–1009)

Beyond just the question of formal appearance, Meton's stated tools (curved ruler, pair of compasses, straightedge) and procedure (quartered circle, radiating lines) are as applicable to the process of construction for fluting at Didyma as they are to the planning of a theater.

Even as a general observation, Vitruvius' method of constructing theaters in plan may hint at the technique of arranging twenty-four equal flutes on an Ionic column.[56] With the blueprint at Didyma and related graphic traces like those at Pergamon and Kos, as well as the benefit of Aristophanes' lines, the notion that long-standing practices in the execution of column drums lent themselves to the new design of the monumental theater by way of scale drawing makes for a seemingly straightforward explanation. After all, in the case of the Pythagorean triangle as a geometric underpinning, one finds the suggestion of a progression



77 Drawings with circular and radial correspondences indicated: the zodiac as a circular construction with twelve equal sectors for the signs (top); the Greek theater (bottom) according to Vitruvius (*De arch*. 5.7.1–2). Drawing author.

from individual Ionic capitals to the blueprint for entasis and the full-fledged scale ground plan of a building like Temple A at Kos (Figures 62, 65).

Still, there is a major difference between this kind of drawing used in the case of Temple A and the Theater of Dionysos. As a product of the second century, Temple A arguably follows on a pattern of designing rectilinear temples in reduced scale going back to Hermogenes in the third century and, before his work, Pytheos (Figure 81). As a related tradition, there are also the radial buildings dating back to the fourth century like those at Epidauros and Delphi (Figures 38, 39). According to Vitruvius (7.praef.12), Theodoros of Phokaia wrote a manual on this tholos at Delphi. As discussed in Chapter 2, the 3:5 ratio in the diameters of the cella and the stylobate of the building at Delphi is repeated in Vitruvius' writing (*De architectura* 4.8.2) and also appears in the Late Republican round temple by the Tiber in Rome. In addition, this is precisely the same integral ratio in the diameters of circular underpinning at Kos (Figure 31). Besides oral traditions, then, written works on the craft of building were available to guide architects in the process of designing their buildings. As a result, by the time of Temple A, ichnography in temples was likely a matter of course. As explored in Chapter 1, however, the same conclusion cannot be said of the fifth century. If the layouts of the Pnyx and the Theater of Dionysos represent exceptions to this conclusion, there are two possibilities. Either ichnography was indeed common in temples of the fifth century despite its apparent lack of integration with (or necessity for) the designs it engendered, or the invention of ichnography took place in the specific context of spaces designed for large gatherings of people focused on individual actions and speakers. Whichever of these two possibilities may have been the case, the available evidence suggests that the transformation of entire buildings specifically according to the tools, techniques, and principles previously applied to the single feature of column drums first happened for places of large-scale communal vision.

In addressing the special circumstance that such spaces for viewing represent, one may therefore account for *why* these in particular underwent the transformation described. As in temples, the traditional form of theaters was rectilinear, a fact that would seem to make the theater no more likely to take on the form of a column drum than a temple building. Instead, there may be something internal to the functions of temples and theaters that would invite the transformation in the latter rather than the former.

In Greek temples, the focus of communal gathering was the altar as the site of ritual in front of the cult building. During sacrifices, the doors of the cella opened to reveal the deity's cult statue framed by the doorway. In this state, the statue now stood (or sat) before the participants, bringing the god into visible presence as the recipient of the ritualistic offering.

Beyond sacrifice, other noteworthy rituals might have taken place before a temple. During the Archaic period, the choral performances of the City Dionysia seem to have taken place in front of the Temple of Dionysos near the southern slope of the Akropolis hill.[57] Here, wooden bleachers were erected to face performances, with the temple as a backdrop. In the early fifth century, when the seating was moved northward to take advantage of the more secure rising slope of the Akropolis hill, the temple backdrop was lost, replaced by a *skene*, the tent for the changing of costumes in the manner of the *orkhestra* in the Agora as the city's other major place for spectacles.

This visual divorce of the temple and the rituals of spectacle would have allowed new considerations for the design of stage sets in order to give a sense of place for the performances of tragedy and comedy. In this context, there appeared the invention of *skenographia*, painting on the *skene* using an illusionistic device to create backdrops that gave a realistic setting appropriate for specific action and dialogue. According to Vitruvius, *skenographia* was first applied in the productions of the tragedies of Aiskhylos (7.praef.11), whose death in 456 would suggest a *terminus ante quem* for this technique that, again according to Vitruvius, was the invention of a painter named Agatharkhos.

Caution is needed in considering what exactly may have comprised the works of Agatharkhos, though certain conclusions about the general formal qualities and chronology of *skenographia* may be drawn. Vitruvius is clear in his description of *skenographia* as radial lines to and from *circini centrum*, the center of a compass-drawn circle as the vanishing point (1.2.2). Yet one cannot know whether this precise definition matches the practice of Agatharkhos as opposed to that of later painters. Aristotle's testimony is consistent with Vitruvius' statement that *skenographia* was an invention of the fifth century (*Poetics* 1449a.18–19), but his placement of its introduction in the tragedies of Sophokles (who overlapped with Aiskhylos early on but flourished after his death) may point to an inconsistency in Vitruvius' and Artitotle's respective sources. Perhaps Agatharkhos invented *skenographia* for the tragedies of Sophokles rather than Aiskhylos. Alternatively, perhaps Aristotle's sources did not recognize Agatharkhos' painted backdrops as proper *skenographia*, whose qualities developed on the work of Agatharkhos with innovations by slightly later painters in the theater of Sophokles.

Conceivably, the earliest *skenographia* in the first half of the fifth century may not have resembled a painting by Masaccio or the theory of Alberti, in which radial lines converge on a central point. Instead, it may have been more intuitive and less systematic, as in Italian trecento paintings wherein axial or parallel lines converge roughly along a central axis. In other words, the new desire for spatial illusionism as a means of evoking a realistic sense of place for drama may have driven an experimental and empirical approach to linear perspective rather than one that was theoretically informed. As Vitruvius tells us (7.praef.11), Agatharkhos invented and wrote about *skenographia*, but his account in turn informed studies by Anaxagoras (ca. 500–428) and Demokritos (ca. 460–ca. 370), who as cosmologists and astronomers presumably would have had something new to add to the topic. Regardless of who first theorized *skenographia* as a circular construction with radial lines converging on a central point, there can be little doubt that this form and the instruments and techniques required to produce it were known in the theater by the time that the fictional version of another astronomer, Meton, described them in the theater in 414.

Before the invention of linear perspective, Greek painters were unlikely to have developed their own independent practices of composing geometric underpinnings with the compass and straightedge. As far back as the ninth century, vase painters created horizontal registers that are circular by nature of the shape of the vessel, as well as other motifs like meander, guilloche, and diaper patterns. These elements of compositional organization and decoration are obviously of a different nature than the use of a compass and straightedge to guide planar relationships, however.

Instead, painters of the fifth century would have learned the craft of technical drawing from those who had long practiced it. Among such cognoscenti would have been those engaged in astronomy, whose methods of inquiry into the movements, distances, and relative sizes of revolving bodies in the cosmos and representations of order employed the graphic medium of technical diagrams. Featured prominently in this tradition were diagrams like those of the zodiac and other drawings based on it.

In drawings like these, the circular and radial construction was a matter of course, capable of representing order itself. As discussed in Chapter 2, in his *Phenomena*, Euclid shows the earth's central location in the universe through a diagram (Figure 34) with an earth-bound viewer's rays of vision radiating outward like the cone of vision theorized in Euclid's *Optics*. These rays protract outward toward the rising and setting constellations, featuring equal lengths from their convergence to the circumference, thereby demonstrating a geocentric structure. Again, what allows this cosmic diagram to "prove" the earth's centrality is nothing other than the initial acceptance that the universe is spherical and surrounded by a circular belt of constellations dividing into twelve equal segments. In addition, as a radial construction showing the complete profile of the belt of signs, the drawing theorizes visual experience of the earth-bound observer's eastward and westward views as an abstract totality imagined from outside his perspective – a representation of seeing itself. To ask a perhaps unanswerable question, what is the origin of this representation of order as a circular and radial graphic construction applied both to the world and how the world is seen?

One possible response *not* favored here is that the origin of this very sense of order may be identified with a single circumstance. As discussed in the excursus below, in the Archaic period, Khersiphron, the architect of the Artemision at Ephesos, designed a mechanism to transport columns by fixing them like axles to a frame of timbers with pivots that allowed wheels to revolve. In this same period, in Anaximander's model of the cosmos, the earth is a column drum on the central axis around which the celestial bodies revolve, suggesting how craftsmanship may have influenced the ways that the form and mechanism of the universe are conceived.[58] In the fifth century, the zodiac used the same construction as an Ionic column for dividing the revolving belt of signs around a central earth. A potentially fascinating conclusion would point to the fluting of the column as the origin of classical cosmology, with the graphic procedure of the former's construction transferred to the zodiac, which in turn transferred to the theater.

There really is no need to concern us with the gaps in evidence one would need to bridge for such an interpretation, however. While the craft of building *may* have had such a direct effect on Anaximander's model of the universe, this need not have been the case. In an alternative hypothetical scenario, Anaximander's column-based model may have been a fabrication of later sources who observed a similarity between the construction for columns and the zodiac, just as a later interpolator may have inserted into Vitruvius' text the comment about the identical construction for the Latin theater and the zodiac.[59]

Regardless of how Anaximander may have actually conceived of the cosmos, another interpretation regarding the connection between the column and cosmic diagrams is more plausible, though again unprovable. As in the innovation of single-axis protraction as a graphic method for the production of entasis and platform curvature, the fluting of columns in the Archaic era need not have proceeded in the manner described here based on the evidence at Didyma and other locations and the dialogue of Aristophanes. Whenever such techniques did come into practice, however, through repetition they would have created habits of working with the compass and straightedge, along with the development of the protractor as a product of these tools. Over time, these working habits would have reified the twenty-four-part radial division and the methods used to produce it as a standard construction for technical drawing.

Against this background, the ancient Greek observation that twelve constellations of stars repeatedly rise, transverse the sky, and set would have encouraged specific ways of envisioning the character of this process. In the first place, familiarity with the mechanics of the wheel revolving on a pivot would have suggested a circular pattern of revolution in the progression of such bodies, although it may be difficult to convincingly demonstrate such a mechanistic conception of nature before the Hellenistic period.[60] More relevant to the geometric interests of Plato and his students, such pivoting would recall the experience of tracing a path with a pair of compasses around a central point. Furthermore, the rosette method of circumferential intersections and the related method of radial protraction would have served the graphic needs of both crafting and theorizing.

As to whether crafting influenced theorizing or the other way around, the hard distinction between these two modes of cultural production itself lacks authority before a relatively late date. Figures like Ptolemy in the Roman Imperial period and Euclid and Plato's student Eudoxos before him are clearly of the theoretical mode, wielding the skills of technical drawing to discover and explain the universe, vision, and geometry in characteristically abstract and internally coherent ways. Before Plato's adoption of *theoria* as a metaphor, however, it is not always easy to strictly separate such an empirical act as making and accounts of making on the one hand (as in written works like those by Khersiphron and Metagenes or the *Canon* of Polykleitos) and accounts of nature on the other. Long after Anaximander built his sundial and sphere of the cosmos, Meton was still building sundials even as he refined the measurements of the year and discovered the cycles of the moon. Similarly, in the *Republic*, Plato could invoke the name of Daidalos in a discussion of truth of velocity in cosmic revolution, just as he could portray the sense of order in the universe as the product of a divine craftsman in the *Timaeus*. Even a writer as late as Vitruvius accepts or perceives the overlap of building, mechanics, and time measurement well enough to classify them as separate departments under the single institution of architecture.

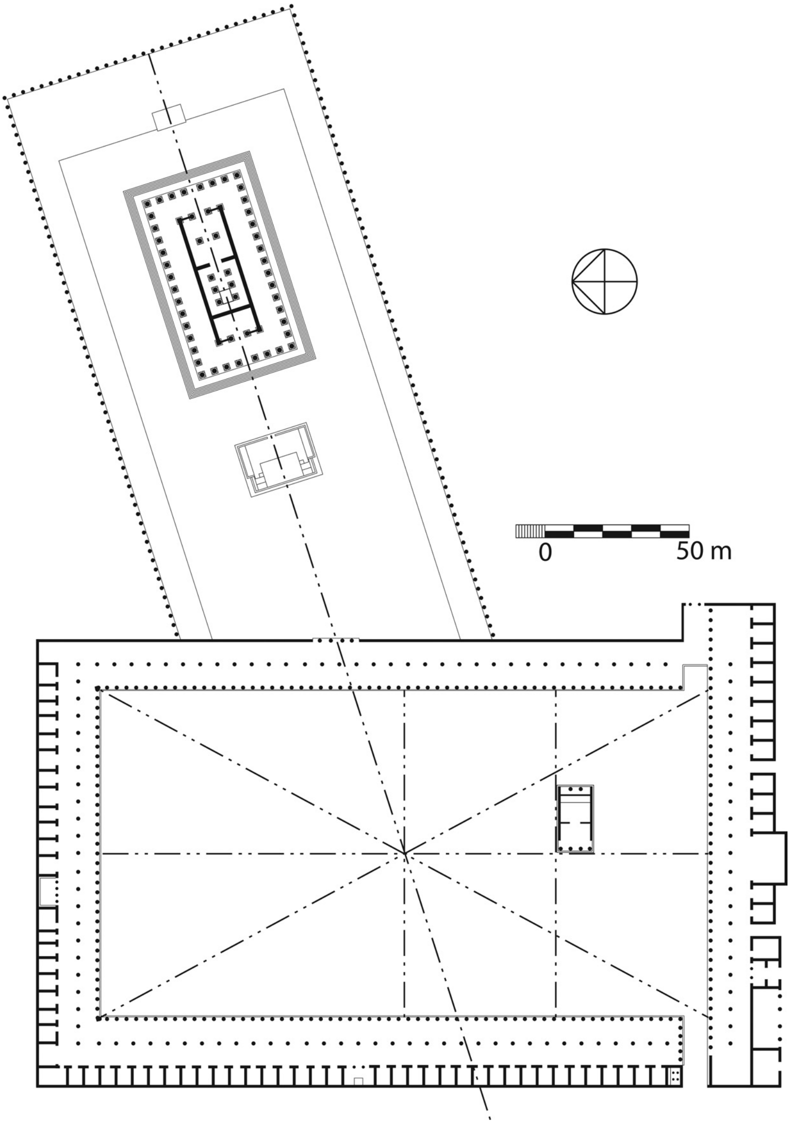
It may therefore be a bit of an overstatement to conclude that building and astronomy shared the same instruments and methods of technical drawing, let alone that one lent these tools and techniques to the other. More accurately, one may consider how building and astronomy were themselves shared by a range of techniques belonging to craftsmanship as a set of pursuits concerned with the presence of order in the world, whether this order is in the visible objects readily at hand or the larger cosmological totality requiring envisioning through theorizing by oral, written, or graphic means. As explored at the end of Chapter 2, Plato himself characterized his dialogues as a form of craftsmanship. Understood in this way, there is no need to imagine any philosopher or astronomer or whomever contemplating the fluting of a column as the model of cosmic order. Upon repetition of the radial division of circles in technical drawing for various purposes over time, the form would have acquired an association with order itself on its own terms.

In the refinement of *skenographia*, a similar development is likely. Whether or not there were any intuitive early attempts at a linear method of creating spatial illusion, the art of painting would have drawn upon existing methods of technical drawing in building construction or astronomy as the arts that had come to rely on such methods. In the hands of those who commonly constructed graphic forms according to radial lines converging on the center point of a compass-drawn circle, a systematic and artificial conceit for understanding how vision works would have been determined according to the same qualities. In a visuality informed by drawing, then, seeing becomes a protraction of radial rays converging on the center of a circle, offering a model for Euclid in the later theorization of optics.

Finally, the new form of the Theater of Dionysos, so widely influential to this day, takes the same circular, radial form as a repetition of the same method of graphic construction. Rather than simply imitating the construction for column fluting, the ground plan of the theater was preceded by the practice of linear perspective employed on its *skene*. *Skenographia* as such applied a device that enhanced the *theatron* as a place for communal vision, unifying the optical rays of *theoroi* (foreign viewers) and *theatai* (Athenian viewers) into a shared experience of rituals of spectacle. By the very principle of radial protraction, at any scale a drawing of this type is capable of extension from its plane outward into the void, pulling in the audience's vision from all directions to look upon a point of focus. Far from a merely decorative concern peripheral to the *theoria* that theaters served, the question of seeing or *thea* was a salient intention of the experience of the *theoros* and *theates*. As Goldhill observes, the theater is precisely the place in which one learned to be a *theates*, and the language of tragedy is filled with repeated, self-conscious references to the act seeing and the importance of looking upon the actions of its characters.[61]

Although the first discovery of radial protraction may have occurred in practices of fluting of columns, then, the evolution from 1:1 to reduced-scale drawing in the craft of building involved another important development. The new organization of the theater as a whole according to a circular, radial construction was not just a transference of the design process of column drums to that of entire monumental building by way of reduced-scale drawing. More compellingly, it was a transference of the geometric underpinning of the vertical surface of the *skene* that projected the visual experience of the *theoroi* and *theatai*, now applied to the hollowed slope of the curved *koilon*. The mode of this transference was planar, drawn at reduced scale on a surface from an abstract aerial perspective to represent the theoretical projection of rays from a perspective outside of the visual experience of the audience. It thereby anticipated the unnatural mode of vision given in the cosmic diagram of Euclid (Figure 34), representing the earth-bound viewer's experience of *thea* from without. In designing a building according to the theoretical understanding of the process of vision in this way, the theater became a complete expression of a place for seeing, reifying the understanding of seeing itself as a radial convergence of rays in space. According to this interpretation, linear perspective as first applied in the Theater of Dionysos in the first half of the fifth century preceded and guided the application of ichnography. As a concept worked through by way of scale drawing, in the words of Vitruvius as well as Aristophanes, this ichnography was an early example of what would meaningfully come to be termed an *idea*.

Although one cannot know whether the new design of the Theater of Dionysos reflects the earliest example of ichnography in Hellenic building, from the standpoint of later theory, it is at least perhaps the earliest recognizably *architectural* application of the practice. Beyond the mechanical and astronomical qualities belonging to *architectura*, Vitruvius defines this institution as inclusive of the more obvious category of the art of building. Traditional to this art, the working through of design graphically on the horizontal plane of the column drum fixes the organization of concrete features (the flutes) that are



78 Artemision and agora, Magnesia-on-the-Maeander. Restored ground plan showing W. Hoepfner's proposed geometric underpinning. Drawing author, modified from W. Hoepfner, in *Hermogenes*: Figure 1.

integral to the visual experience of the building. If Archaic and Classical temples employed ichnography, by contrast, they did so in ways that one cannot readily appreciate in a manner that connects the experience in three dimensions to the instruments and methods of technical drawing that produced them. Yet in the Greek theater (Figure 77), the radial construction with the compass and straightedge establishes the rising forms of the *koilon* and its aisles.

The invention of this new form for theaters introduced a similarly new way of shaping all buildings according to the craft of technical drawing by way of ichnography – a progeny that transcended the theater as an isolated type. The round building at Delphi (Figure 38), with its circular placement of twenty columns, represents a protraction of the same radial arrangement of the fluting of its Doric columns. In a less internally coherent way, the round temple by the Tiber repeats the Delphic building's 3:5 diameters as well as its arrangement of twenty columns,[62] even though the columns of this Roman building now feature the twenty-four divisions of the Corinthian order. Beyond circular buildings specifically, the use of ichnography to guide the total design of buildings extended to traditional rectilinear temples as well (Figures 23, 81). Furthermore, the radial and axial approach to designing theaters could even extend to the designing of relationships across voids within and between complexes, as in the binding of the sanctuary of Artemis Leukophryne and the neighboring agora in Magnesia-on-the-Maeander (Figure 78).[63] In a fascinating way, therefore, the graphic means of shaping space begins as a way of articulating the plastic surfaces of columns in traditional buildings, which themselves existed as self-contained, sculptural expressions. With the aid of Vitruvius and the Greek sources his writing reflects, the principles that drove such processes of design in individual temple buildings and ultimately their settings are explored in the following chapter.

FOUR

ARCHITECTURAL VISION

One of the chief aims of Vitruvius' treatise was to convey that *architectura* is more than a practical pursuit. In the words of Andrew Wallace-Hadrill, rather, it is "an expression of deep rational structures, of *ordinatio* and *dispositio*, of *eurythmia* and *symmetria*, that can give to the built environment a logic and order that is underpinned by the deeper logic and order of nature."[1] There is no reason to doubt that Vitruvius himself truly believed in this view of architecture and the ordering power of the procedures and principles of Greek origin (*ordinatio*, *dispositio*, *eurythmia*, and *symmetria*) of which architecture consists. Yet Vitruvius likely would have been surprised by the present study's suggestion that the structures and mechanisms of nature reflected in architecture were born of a particular way of seeing that itself came into being largely through repeated habits of drawing in the art of building. This final chapter continues this theme by focusing on Vitruvius' writing about the Greek methods and criteria of good drawing that define the *ideai* of architecture (ichnography, elevation drawing, and linear perspective) and the observable presence of these qualities in the physical products of the techniques that produced them. Lastly, it briefly addresses the shaping of space in Hellenistic and Roman buildings and complexes as an outcome of a particular kind of vision in the architecture leading towards and postdating Vitruvius.

Nature and Architectural Vision

In addition to what Polykleitos' *Canon* and its emphasis on *symmetria* may have owed to architectural theory, the influence may have run in the opposite direction as well. Vitruvius explains the necessity of commensuration in the design of temples by way of the human body, which features integral relationships between individual parts and the whole, as in the 6:1, 8:1, and 10:1 ratios between the total height of the body and the length of the foot, head, and face, respectively (*De architectura* 3.1.1–4). Furthermore, there should be additional commensurations between the limbs, and Vitruvius credits the famous painters and sculptors of antiquity for the employment of such commensuration based on proportion (ἀναλογία) in their works. Elsewhere, Vitruvius includes Polykleitos among the most renowned of Greek sculptors (1.1.13, 3.praef.2). It is therefore likely that, beyond general influences that the Roman architect reflects, he may very well have had Polykleitos directly in mind in his own writings. As such, the "many numbers" that architects of Vitruvius' time worked through arithmetically on the basis of desirable proportions appears to have had something in common with the working methods of sculpture.

Nonetheless, for Vitruvius, these correspondences between the body and the temple take on a distinctly architectural character:

> Similarly, indeed, the elements of holy temples should have dimensions for each individual part that agree with the full magnitude of the work. So, too, for example, the center and midpoint of the human body is, naturally, the navel. For if a man was to lie on his back, with outstretched arms and feet within a circle whose center is at the navel, his fingers and toes will trace the circumference of this circle as they move about. But to whatever extent a circular scheme may be present in the body, a square design may also be discerned there. For if we measure from the soles of his feet to the crown of his head, and this measurement is compared with that of the outstretched hands, one discovers that this breadth equals the height, just as in areas which have been squared off with the set square (3.1.3).[2]

This is the description of the "Vitruvian man" (Figure 79) so compellingly illustrated by Leonardo during the Renaissance, albeit with his own divergences from the ancient formula.[3] The passage takes the temple's analogy with the body beyond the arithmetical considerations of proportions underlying figural sculpture or a building of the Classical period like the Parthenon, and moves design into the realm of geometry. In doing so, it suggests the idea of the compass, a basic tool of technical drawing, centering it at the point of the navel and constructing a circumference that the fingers and toes of the rotating limbs will touch. What Vitruvius evokes here is ichnography, a geometric plan drawn with a compass and straightedge that describes the interrelationships of the temple's forms by way of the analogy of a supine man against the plane of the ground.[4] In addition to Vitruvius' acknowledgment of the existence of the practice by his time (1.2.2), then, we have an explicit and rather colorful explanation of it.

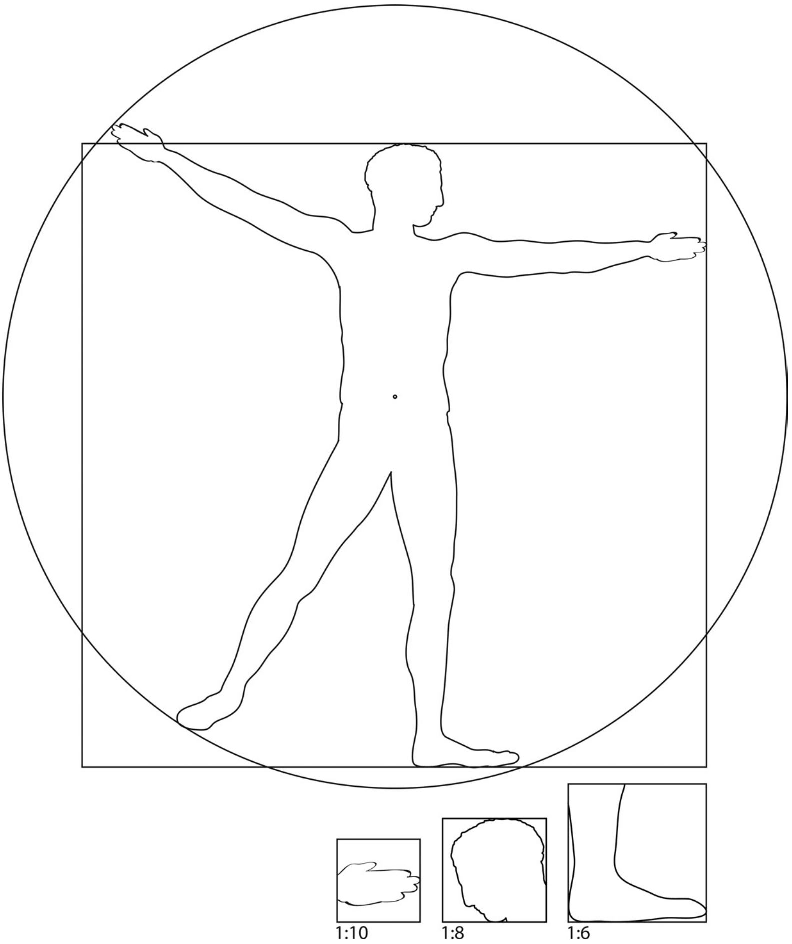
In one sense, the description of a man and a temple according to numbers and geometry is consistent with a certain mathematical way of viewing the world. Again one may cite Plato in this regard, but it is also instructive to note descriptions of actual objects. A passage in Strabo preserves the description of a particular tree according to Attalos I of Pergamon:

> Its circumference (περίμετρον) is twenty-four feet; and its trunk rises to a height of sixty-seven feet from the root and then splits into three parts equidistant from one another, and then contracts again into one head, thus completing a total height of two plethra and fifteen cubits. (Strabo 13.1.44)[5]

Attalos' use of mathematical language to describe a natural form in terms of integral dimensions of circumference, height, and isometric intervals between parts shows a level of abstraction akin to Vitruvius' description of a human body. Neither captures the variation and irregularity of real forms in the world, conveying instead the elements of number and spatial composition. Despite the strangeness of this tree that Attalos describes, it is not the physical particulars that inform his account, but rather the mathematical considerations of quantity and shape that defines the tree's primary nature, its *idea*.

One way of explaining this mode of vision may be through reference to the philosophical interests of the Attalids. Preceding and following Attalos I, Pergamene rulers generously supported the Academy in Athens. Over time, the heads of the Academy included four separate philosophers from Pergamene territory.[6] In Platonic idealism, it is not the sensory apprehension that is valued in and of itself. Rather, the value lies in what the experience of seeing can teach one about eternal, transcendent reality. Understood in this way, the accidental irregularities of physical features may be less privileged, less eternal, and less "real" than the metaphysical underpinning from which they imperfectly derive. Beyond even a conscious intention to geometrize objects in verbal or graphic representations, the mathematical qualities of objects may already form at the level of intuition. Cultural tendencies certainly would have guided the ways in which educated subjects of the Hellenistic world saw objects. In other words, visuality, or the practices of seeing that depend on the cultural and social background that conditions vision, may have determined representation from the outset.[7] Idealism as such need not have reflected chosen beliefs. Instead, to some degree, it may have been a habit of viewing, thereby influencing the ways in which a monarch or architect educated during the Hellenistic period described bodies in space. As graphically rendered descriptions of buildings, then, architectural drawings were *ideai* in the most appropriate sense.

In addition to this idealist quality, there is a second, more mundane explanation that can account for these descriptions by Attalos and Vitruvius. Rather than just alluding to the existence of a transcendent realm or universal numbers and geometry or reflecting the perception of certain subjects, these passages may be understood to deliberately provide a sense of *order* to the objects they



79 Human form defined by sample modules, proportions and geometry, as described by Vitruvius (*De arch.* 3.1.2–3). Modules here shown with their respective ratios with the overall height/breadth. Drawing author.

describe by doing away with the distractions of detail. In the case of the tree, the geometry and whole numbers effectively give the reader the general information of shape and scale needed to accurately imagine the visual experience of this object in the mind's eye. In the Vitruvian man, the integral proportions and geometry allow for a standardized composition of bodily form that illustrates the necessity for temples to feature a similar "correspondence between the measure of individual elements and the appearance of the work as a whole."[8] These alternative philosophical and practical interpretations are not mutually exclusive, and it may be noteworthy that for either purpose, the idea of order is conceived of and conveyed by the idealizing means of number and geometry. Whatever the actual motivations behind these ancient passages might have been, however, a proper description of how these passages work in the imparting of an aesthetic of order is not contingent on the nature of their relationship to Platonic idealism. It is this prescriptive element of formal order, described in theory intended for practical execution in architecture, that I address briefly here.

Despite their conceptual resemblances, what separates the descriptions of Attalos and Vitruvius is the latter's association with design theory. Rather than merely articulating a set of observations, the Vitruvian man illustrates the qualities of architecture, a point emphasized in a separate discussion of commensuration appearing in the specific context of Greek architectural drawing: "Just as in the human body there is a harmonious quality of shapeliness expressed in terms of the cubit, foot, palm, digit, and other small units, so it is in completing works of architecture" (*De architectura* 1.2.4).[9] The expression of this shapeliness or *eurythmia* results from a procedure to be followed for the three different types of *ideai*, including ichnography, elevation drawing, and linear perspective or *skenographia* (1.2.1–4). Vitruvius defines ichnography as "the skillful use, to scale, of compass and straightedge, by means of which the on-site layout of the design is achieved" (1.2.2).[10] Vitruvius is equally prosaic in his characterization of the primary purpose (among others) of geometry in an architect's education as learning to use the compass and straightedge in executing a building's plans (1.1.4). This execution, then, follows a practical two-part procedure (1.1.2).

The first part, in Greek called *taxis* (Lat. *ordinatio*), is the process of establishing *quantitas* (Gk. ποσότης), whose meaning in Vitruvius' architectural sense goes beyond the strictly arithmetical sense of quantity as number.[11] Rather, it is the creation of modules taken from the parts of the building, as well as a successful composition of the whole that expresses these modules. As Vitruvius describes, this *quantitas* is the foundation of *taxis*, wherein an integral and universal commensuration – in Greek called *symmetria* – is created through proportional interrelationships shared between the individual modules and the building in its entirety, indicating a system based on integral rather than irrational numbers.[12]

Architecturally, then, *taxis* is the establishment of a building's layout where modules are proportionate to the overall scheme. Nowhere does Vitruvius strictly state that this process of construction should be geometric. Nor does his text give any indication that irrational numbers resulting from measurements like the diagonal of a square play a role in the development of the composition, which indeed would undermine the dependence of *taxis* on *symmetria*. Rather, as a graphic construction defined by clearly measurable elements and the intervals that separate them, *taxis* is the execution of shape according to arithmetical principles. Naturally, however, the overall composition would appear geometric in the aesthetic sense of archetypal polygons or circles, albeit characterized by integral proportions. In any case, this *taxis* is not the completed architectural drawing, but rather one of two indispensable parts in its realization.

The other part of the Greek procedure is *diathesis* (Lat. *dispositio*). It is "the apt placement of things, and the elegant effect obtained by their arrangement according to the nature of the work."[13] In other words, the modules and overall shape emerging from the *taxis* composition inform the dimensions and placements of the architectural elements, and vice versa. How this process works at the level of a drawing like an ichnography is illustrated by analogy to the human form, which nature provides as a model for good design. In the Vitruvian man, a module like the foot forms a 1:6 integral ratio with all the parts taken together. In turn, all these parts are commensurate with the square that underpins the height and breadth of the figure. This and similar ratios are also implicit in the circle that describes the outer extent of the rotated limbs (Figure 79).

With respect to the other correspondences that the Vitruvian man shares with the descriptions of *taxis* and *diathesis*, however, this last mentioned feature creates a note of ambiguity: There is no explicit integral commensuration between the circle's diameter and the breadth of the square. A sense of measure may still extend to this diameter by way of the modular underpinning of obliquely placed limbs, but it requires some flexibility of mind and imagination to realize this. One possible explanation for this divergence is that it shows us the human element in design, and that one should avoid expectations of strict conformity between theory and practice. Another possibility is that the theory itself addresses precisely this human element. Upon introducing the three types of architectural drawing (ichnography, orthography, and perspective) in his discussion of *diathesis*, Vitruvius writes:

> These types are produced by analysis (*cogitatio*) and invention (*inventio*). Analysis is devoted concern and vigilant attention to pleasing execution, *cura studii plena et industriae vigilantiaeque effectus propositi cum voluptate*. Next, invention is the unraveling of obscure problems, arriving, through energetic flexibility, *vigore mobili*, at a new set of principles. These are the terms for design, *dispositio*.[14] (1.2.2)

Significantly, this devotion to a good result and the "energetic flexibility" required to work through the challenges of design both pertain to Vitruvius' discussion of *diathesis* (= *dispositio*) rather than to *taxis*. This context makes it clear that *diathesis* need not be a rote placement of architectural features according to the composition worked out at the level of *taxis*. Instead, upon realizing the modular basis for the drawing, the geometry of the design emerges through analytical and creative approaches aimed at making a pleasing shape by means of principles independent of those established through *taxis*.

Vitruvius offers explanations of two additional Greek terms in order to flesh out the procedures of architectural drawing (1.2.3–4). He defines *symmetria* as a commensuration both of the parts to one another and to the entire figure (1.2.4), thereby clarifying its compositional role in *taxis* as a quantity (ποσότης) expressed by modules that serve as the measure for the drawn composition in its entirety (1.2.2).[15] The other Greek term is *eurythmia*, a word with an obvious association to musical theory that Vitruvius explains as the pleasing and coherent appearance in a drawing brought about when all parts of the work in all directions (height to width, length to breadth) are proportionally unified with the whole.[16] These two definitions seem quite similar, and indeed they are. They are not, however, synonymous. By comparison, Greek poetry has its meter (μέτρον) and rhythm (ῥυθμός).[17] These terms are also nearly identical in their definitions. While meter establishes quantity through feet given by long and short syllables, rhythm unites with meter by instilling phonetic values in the sequence of chosen words. Meter and *symmetria* give measure to the composition, but neither of these *are* the composition. Rather, the art of the poem or drawing emerges only through the unity of measure and rhythm or *eurythmia*, creating a sense of harmony that is unmistakable to the trained ear or eye. Through measure and good form, both the verbal and graphic art achieve an expression of *order* that stands apart from everyday speech and visual experience.

Vitruvius is explicit in relating his discussion of *ideai* with the human body (1.2.4), and the Vitruvian man offers an analogy with ichnography in particular. In this celebrated passage, one may discern the Greek qualities of design at work as defined by Vitruvius. This correspondence takes place not by intention, but rather by Vitruvius' habits of mind as an architect who came of age at the end of the Hellenistic period. Naturally, his discussion of temple design through a drawing composed with the compass and straightedge reflects his explanations of the qualities of Greek architectural drawing that he obviously knew well enough to describe elsewhere in his text. The Vitruvian man, then, has *taxis* in its selection of parts – the foot, palm, head, and so forth – that serve as modules expressing *symmetria* through integral ratios with the body as a whole. Through analysis and invention, the hands are aptly placed (*diathesis*) so that the span serves as an axis running orthogonally to that of body's length running from foot to head. This *diathesis* thereby establishes a proportion of 1:1 between the x and y dimensions, an overall ratio that yields the *eurythmia* of the square. In turn, the square articulates the modules of which it is composed, all taken together as *quantitas*, thereby expressing the *symmetria* of parts to each other and the whole and therefore, again, its *taxis*. Further analysis and invention rotates the limbs in order to place the hands and feet in positions that express *eurythmia* through the shape of the circle. By adhering to a process that aims for both commensuration and "good shape" in composition, the architect employs the qualities proper to nature's design of the body as a means of shaping order in space. As a result, the representation or *idea* of a temple at the level of ichnography acquires arithmetical and geometrical principles that define the relationships of its parts to the whole.

In one possible reading, the geometry of the Vitruvian man may appear to show a conceptual difference from the geometry that would underlie an actual ichnography in the design process. In such a drawing, geometry would truly generate the composition by way of *taxis* and *diathesis*. In the Vitruvian man, however, the body is already given as an example idealized from nature, and it is the body itself that generates the geometry. The passage cannot, therefore, be understood to serve as a set of instructions for architectural design.[18]

Additional considerations may expand on this reading's implications for the classical design process. Although the human body is indeed already at hand, Vitruvius clearly states who it is that is responsible for its design: It is Nature itself that composed it (3.1.2). Although such a poetic-sounding notion can hardly equate to a "how-to guide" for architects designing temples, its intended didactic value for the design process is beyond doubt. Upon completing his description of the circumscribed body, Vitruvius states:

> And so, if Nature has composed the human body, *Ergo si ita natura composuit corpus hominis*, so that in its proportions the separate individual elements answer to the total form, then the ancients, *antiqui* (i.e., earlier Greeks) seem to have had reason to decide that bringing their creations to completion likewise required a correspondence between the measure of individual elements and the appearance of the work as a whole.[19] (3.1.4)

The passage is not prescriptive. It does, however, offer a theoretical justification for the principles of design it espouses: *symmetria* and *eurythmia*, and the resulting geometry of form that these principles give rise to.

More importantly, the Vitruvian man helps propagate and reify a concept that Vitruvius takes from his Greek sources, and with which some of his Latin-speaking readers may be relatively less familiar: the relationship between geometry and nature. If one accepts that the text describes the body as originating in nature rather than an architect's tools and geometric procedure,[20] a new issue arises: Namely that geometry is supposedly inherent in the natural human form. The discernment of a circle and a square present in the spatial order of the body presupposes practices of abstract viewing that are anything but natural and universal. It is only within a culture that is to some degree *focused* on graphic forms created with the compass and straightedge that people would claim that such a composition is given in nature, as in Attalos I's description of the tree in terms of circumference and equidistant trifurcation.

Yet it would be overly facile to fully equate Attalos' account with the Vitruvian man. In addition to the important difference of their context emphasized earlier (mere description versus design theory), one may separate Attalos and Vitruvius according to their respective subcultures. As a patron of learning concerned with the intellectual trappings of monarchy, Attalos I was likely quite familiar with the kinds of philosophical and mathematical traditions of Plato's

Academy that would have informed his idealizing description. Vitruvius, too, knew Plato, though it is not the relative shallowness of his knowledge that sets him apart from the Hellenistic *basileus*.[21] Rather, it is as an architect in Rome, rich in the traditions of Greek architectural practice and theory dating at least as far back as the arrival of the Greek Hermodoros of Salamis in the second century,[22] that Vitruvius writes. Regardless of the degree of his familiarity with philosophy, his architectural upbringing was defined by a devotion to design according to the principles he describes. Given his experience, it should be no surprise that he conceived of objects and the spaces they define precisely in terms of the whole-number proportions, modular commensuration, and crystalline and circular shape of the *idea* as constructed with the compass and straightedge. Whatever his awareness of philosophical idealism may have been, then, this repeated experience would have solidified his visuality to the point that he could assert that one finds geometry in the products of nature.

Additional comments by Vitruvius underscore this lack of conformity with philosophy. Haselberger fully documents Vitruvius' understanding of refinements.[23] In explaining the motivation behind platform curvature, Vitruvius emphasizes the need for this "addition" of mass to the center in order to correct the optical impression of concavity that takes place when viewing horizontal lines (3.4.5). Elaborating on this issue of optics (6.2.2), he states that sight does not bring about true impressions. Often, rather, the mind is confused by visual judgments. Close comparison of several passages in Vitruvius, Philon Mechanikos (*On Artillery* 50–51), and other Greek writings leaves no doubt that this approach to refinements by way of addition and subtraction was a feature of architectural theory antedating the late third century. These clear and specific textual correspondences have been thoroughly and eloquently elaborated on elsewhere and will not be repeated here.[24] Their importance shows that, as reflected in Vitruvius, Hellenistic architectural theory shows a tendency to reverse Plato's hierarchy. Instead of the role of vision as the sumptuous gift of God for the aid of understanding that may lead one toward a higher seeing aimed at truth as embodied in the realm Ideas, it is rather the eye itself that the design process serves.

This clear correspondence between Vitruvius' commentary on refinements and that of Greek writers raises the question of whether the Roman author's account of ichnography finds similar support in a Greek context. From Priene comes an inscription that may testify to the association between ichnography and temples in the second century. It identifies one Hermogenes as having dedicated "the *hypographe* (ὑπογραφή) of the temple, which he also executed."[25] One cannot know whether this Hermogenes is the celebrated architect who, according to Vitruvius, designed the temples of Artemis at Magnesia and Dionysos at Teos,[26] but the term *hypographe* does suggest the idea of a drawing having at least something to do with the notion of what is below or at the bottom, and therefore possibly consistent with the idea of being viewed from above.[27] *Hypographe* normally refers to an outline as distinguished from a detailed image,[28] and an inscription from a separate architectural context uses the term in reference to determining the details of elements, not the layout of entire buildings.[29] An additional complication arising from the inscription from Priene is its commemoration of a dedication, suggesting the function of this particular *hypographe* to be something other than a part of a planning process as discussed by Vitruvius and other Roman sources.[30] In the face of this single available piece of evidence, therefore, we are left with a term whose meaning is unclear, and which provides no textual confirmation the role of ichnographies in the design process of Greek prismatic buildings like temples.

Therefore, we depend entirely on Vitruvius for the theoretical background of ichnographies. His text makes it apparent that the issue of refinements serving as optical corrections is part of a larger concern. In a discussion of proportion and optics (6.1.1), he writes that the most important issue for an architect is the establishment of a system of *symmetria*. Once establishing this and relating its proportions to the actual dimensions to be built, a good architect will then take into account the buildings' appearance, location, and intended use and, based on these considerations, will "make adjustments . . . should something need to be subtracted from or added to the proportional system, so that it will seem to have been designed correctly with nothing wanting in its appearance."[31]

This emphasis on correct appearance by means of additions or subtractions is found repeatedly throughout Vitruvius' text.[32] With this sentiment, Vitruvius and his Hellenistic sources repeat Polykleitos' dictum as given by Philon: That "the good" emerges from the small departures from the many numbers arrived at by the designer. The creation of *symmetria* is of inestimable importance, but its modification by way of analysis, invention, and *eurythmia* is essential to good architecture. These, too, are procedures and principles of the *idea*, which are worked through by means of *taxis* and *diathesis*.

With all of these considerations in mind, it would appear that idealism in architecture shows similarities with Pythagorean and Platonic thought, but also significant differences. The *idea* is worked out through the process of drawing, and indeed it is the drawing. As in the *Meno*, Sokrates or a geometer will draw in order to discover and demonstrate certainties through two-dimensional spatial properties and measured relationships. An architect will use the same tools of technical drawing with an eye to shaping proportionate and modular spatial relationships that, above all, appear or feel right to an architect who is skilled enough to know. In carrying out small departures from the true proportions, the architectural design process goes beyond the interests of mathematics and philosophy.

Before returning to the actual Greek buildings, a brief synthesis of the theoretical considerations discussed so far may be useful. In his account of architectural drawing and its Greek terminology at the close of the Hellenistic period, Vitruvius writes as though ichnographies in the design process were a matter of fact. His prescription for designing temples employs the analogy of the human form, described as a ground plan drawn with the compass and exemplifying how taxis, diathesis, symmetria, and eurythmia define spatial order. As an *idea* described by number and geometry, the "Vitruvian man" evokes a sense of philosophical idealism that similarly characterizes the way that many educated persons likely viewed the world. Yet classical ichnography need not be understood simply as either a precise parallel or an expression of Platonic or Pythagorean traditions. As a part of architectural design, rather, it was a product created by professionals who habitually drew with the compass and straightedge in their creation of columns and theaters and refinements through single-axis protraction – a repeated practice that seems likely to have informed the way architects would have seen objects in nature in terms of regularized geometric form. Furthermore, the practice of architecture and sculpture both carried traditions of working with *symmetria* going back centuries, as in the proportions observable in the Parthenon and those referred to in the *Canon* of Polykleitos, at least insofar as later comments about *symmetria* purport to represent Polykleitos' views. As seen in the refinements that appear in Classical buildings and in Philon Mechanikos' possible reference to *para mikron* as small deviances from the numbers, architects and sculptors were primarily in the business of creating pleasing form for sensory experience.

Regardless of the nature of the beliefs of individual Greek architects, impenetrable as they are without direct testimony, this practical consideration differentiates *ideai* in architecture from *ideai* in philosophy. Reference to philosophy itself, particularly the Platonic elevation of *ideai*, would arguably make for an unsatisfactory justification for the employment of *ideai* in the design process of any Greek building. Following the transformation of the theater as vessel for communal vision expressed through *skenographia* and the planar conception of ichnography, the practice of planning buildings geometrically at reduced scale entered into the architect's process of design in explicit ways. Before and after this transformation, the process for drawing the fluted drum of a column suggested the principle of spatial protraction, as well as a model for order given by both the square of a quartered circle and the modular commensuration of the fluted circumference. In addition to the radial configurations of round buildings like those at Delphi and Epidauros, the application of the oft-repeated forms of axis, circle, and square along with the principles of protraction and *symmetria* stood ready in the envisioning of any building from an abstract aerial view directly above, as abstract as envisioning the universe itself in the form of a twelve-part zodiac or a supine man composed of distinct, commensurate parts.

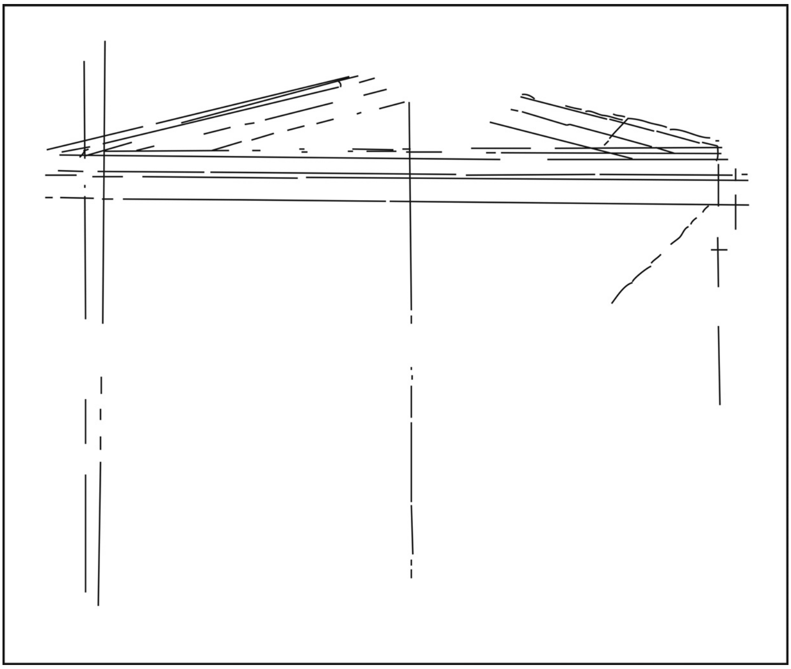
Even if the fluted column indeed established the originating model for this mode of seeing in cosmic diagrams, linear perspective, and buildings, surely it was the repetition of the tools and techniques of such constructions that determined both the perception and shaping of the environment. If born of linear perspective as argued in Chapter 3, through such repetition over time, ichnography became a particularly architectural vision.

ICHNOGRAPHY IN THE IONIAN TRADITION OF PYTHEOS AND HERMOGENES

The tradition of ichnography in rectilinear buildings likely dates at least as far back as the Temple of Athena Polias by Pytheos, begun in the Late Classical period in ca. 340.[33] The indication for ichnography is the easily discernable grid that underpins the temple's ground plan, establishing an approach to architectural design still found in the work of Hermogenes more than a century later (Figure 23), and indeed countless temples throughout the Roman period.[34] This grid is based on axial distances between the columns that are double the width of the plinths. In other words, the plinths serve as the module that expresses commensuration with the axial distances (two modules), and the dimensions of the naos along the axes of the walls and antae (six by sixteen modules), the axes of the peripteron (ten by twenty modules), the stylobate (eleven by twenty-one modules), and the total ground plan on the krepis (twelve by twenty-two modules).[35]

The idea that Pytheos worked out this system with reduced-scale drawing may find support in a relatively recent discovery. On an ashlar block built into the temple of Athena Polias at Priene appears a nearly completely preserved incised drawing of an entablature and pediment (Figure 80), which is thought to relate to the pediment of the temple itself.[36] As in the working drawings discovered at the Hellenistic Didymaion, the example from Priene shows how Greek masons and architects worked out their designs on ashlar blocks. Upon covering these surfaces with red chalk, the use of a graver with a straightedge and compass rendered drawings whose white linear incisions stood out with clarity against their surrounding color.[37] Monumental drawings of pediments are found elsewhere, as in the drawing used in the design of the naiskos of the Didymaion incised into the adyton's western wall and the working drawing for the Pantheon's façade incised on the marble paving before the Mausoleum of Augustus in Rome.[38] The preserved width of the drawing from Priene, however, is less than 48 cm. If this drawing truly relates to the temple's design, it would indicate that Pytheos sketched in reduced scale, suggesting that the architect perhaps likewise worked through his ground plan.

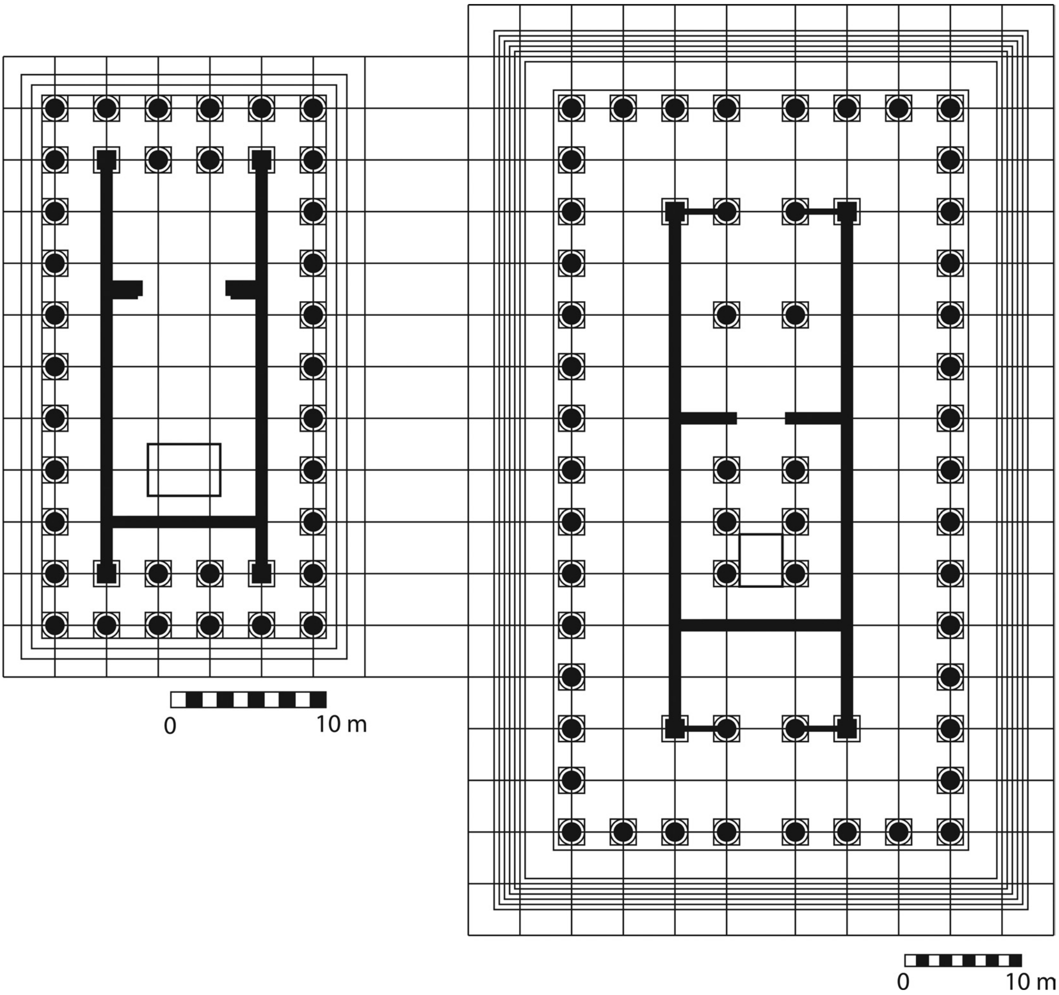
Whether or not Pytheos' scheme may have carried much influence for the practice of ichnography in his own time,[39] its relevance for Hermogenes in the



80 Temple of Athena Polias, Priene. Restored drawing of a cornice and pediment incised into a block built into the temple. Width: ca. 47¼ cm. Drawing author, modified from J. Misiakievicz, in Koenigs 1983: Figure 1.

following century is apparent.[40] The primary mode of transmission for his ideas may have been his writings about his design process, establishing a discourse for the design of Ionic temples that Hermogenes both read and contributed to with his own publications on the temples of Artemis Leukophryne at Magnesia-on-the-Maeander and Dionysos at Teos (Figures 81, 83).[41] In addition to applying the grid-based layout, the latter of these is virtually a copy of Pytheos' temple at Priene (Figure 81).[42] In this context, one may recall the inscription from Priene that identifies Hermogenes as having executed and dedicated the *hypographe* of the Temple of Athena Polias. If this inscription indeed refers to the architect of the temple at Teos, then Hermogenes may have dedicated an ichnography as a monument in its own right that demonstrated the system he learned through the writings of his forbearer,[43] perhaps inscribed on stone in the manner of working drawings like the one discovered at Priene (Figure 80).

Regardless of this possibility, Hermogenes generally did not slavishly copy either Pytheos' forms or the system that determined their placements. Rather, his ichnography shows a creative flexibility in the composition of spatial order. Along the length of the center of his Artimesion's ground plan (Figures 23, 81), he widened the axial distance of the columns by one-third.[44] In addition, the temple's arrangement is octastyle rather than hexastyle, and the axial placements of the outer columns coincide with the second rather than the neighboring axes



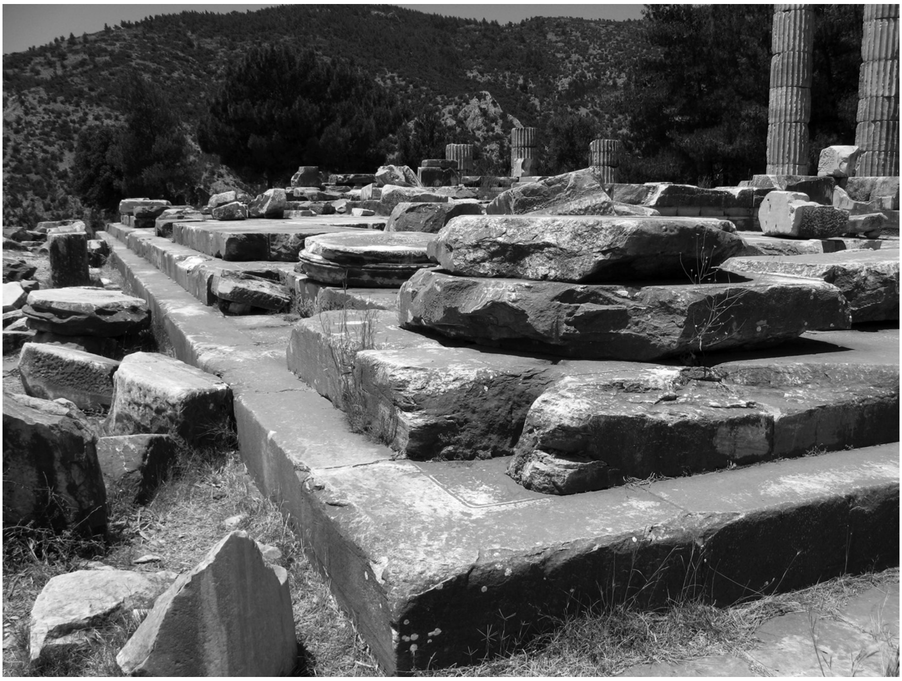
81 Temple of Athena Polias at Priene begun ca. 340 B.C. by Pytheos (left) and Temple of Artemis Leukophryne at Magnesia-on-the-Maeander (right) begun ca. 220 B.C. by Hermogenes. Comparison of grid-based ground plans. Drawing author, modified from J.J. Coulton, in Coulton 1977: Figure 23.

beside the walls of the naos. Although the "empty" axial intersections of the grid could accommodate an additional inner row of columns in the manner of dipteral arrangements, Hermogenes' scheme creates an expanded interior space on all four sides of the peripteron. The result is a pseudodipteral temple, which Vitruvius claims is the invention of Hermogenes (*De architectura* 3.3.8).

Hermogenes' Artemision is not the earliest example of the pseudodipteral type, which goes back to the Archaic Artemision at Kerkyra and other examples,[45] but Vitruvius' assertion of his inventive role is still probably correct. After all, Hermogenes is unlikely to have known antecedents created in the traditions of the Greek mainland and southern Italy that were distant in time and space from his own experience. As a student of the Ionian tradition of Pytheos, he may have discovered the arrangement not through awareness of earlier examples of widely spaced ptera, but rather through the process of design that Vitruvius describes in terms of *diathesis*. Beyond just *taxis*, where in this case the temple's grid is created through modules based on the dimensions of the plinths, *diathesis* takes place through "concern and vigilant attention to pleasing execution" and "the unraveling of obscure problems, arriving, through energetic flexibility at a new set of principles."[46] In doing so, the practice of reduced-scale drawing allows for an analytical and inventive composition through the planar geometry of the grid, resulting in an entirely new conception for architecture that bears only a chance typological resemblance to earlier works. Beyond this resemblance, ichnography creates the pseudodipteros as positive expression of spatial order rather than just an intervening absence of mass.[47]

This "analysis" and "invention" by way of "energetic flexibility" in *diathesis* results not only in interesting new formal explorations, but also in subtle departures from the established *taxis* in the temples at both Priene and Magnesia. In addition to fractional deviations in the measurements of elements and dimensions in Pytheos' temple, neither the wall of the doorway leading into the cella nor the wall separating the cella from the opisthodomos conform to align with the theoretical axes of the grid in the manner of the other features (Figure 81).[48] In Hermogenes' temple, the two rows of three columns within the cella similarly do not align with their grid, separated lengthwise by axial distances of 3.60 m rather than the distance of 3.94 m that defines the length of all axial divisions throughout the temple's grid.[49] Such minor departures create exceptions from the integral proportional relationships defined by the grid, articulating a method of design that seems in the spirit of the Polykleitan statement concerning "the good" arising from small deviations (παρὰ μικρόν) from the numbers (Philon Mechanikos *On Artillery* 50.6.).

As discussed in Chapter 1, such deviations in the Parthenon find their most salient expressions in the third dimension with refinements like curvature, inclination, and adjusted levels (Figures 20, 21). Similar platform curvature is observable at Priene as well (Figure 82),[50] but what separates the Parthenon's design from Pytheos' temple is the latter's relative *independence* of alterations in plan from features in the elevation. In the Parthenon, the departures from the standard 4:9 ratio found in the relationship of column diameters and their axial distances are the contractions in the corners and across the façades that respond to deviations in the placement of triglyphs in the frieze. That is to say, traditional considerations of Doric design in the elevation necessitated alterations in the plan. By contrast, the off-axis placement of the wall of the opisthodomos at Priene enabled the option of a more spacious ambulatory surrounding the axially placed base for the cult statue, and the contracted distances separating the columns of cella at Magnesia allowed for a tighter three-dimensional frame for



82 Temple of Athena Polias, Priene. West flank viewed from south showing curvature. Photo author.

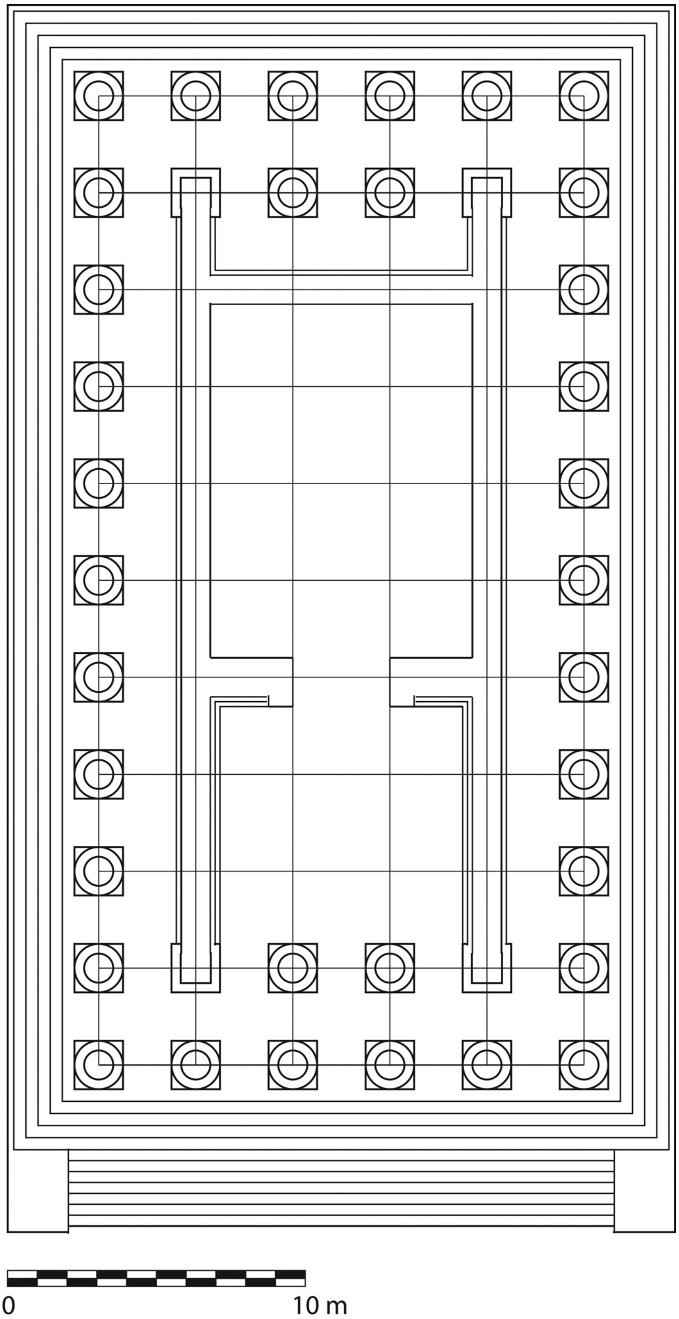
its statuary base (Figure 81). Whereas the Parthenon's design is conceived of in primarily sculptural terms that reflect in subtle changes in the ground plan, then, the ground plans at Priene and Magnesia show small departures from nothing other than the geometry that orders the placement of the majority of the temples' features. Such exceptions underscore both the primacy of ichnographies in the Ionian process of design and their existence as real entities in the classical world rather than our own modern assumptions about how a building should be composed. As a geometric underpinning that architectural features either conform to or slightly deviate from, the grid is a graphic component separate from the material forms, guiding their placements according to well-established principles as well as good aesthetic judgment.

In confronting these Ionian ichnographies, one may appreciate their foreignness with respect to our own architectural traditions. Ancient practices of ichnography seem to have been completely lost during the course of the Middle Ages and had to be invented anew during the Gothic period.[51] As developed during the Renaissance, the use of grids in modern ichnography shares only a superficial resemblance with the systems of Pytheos and Hermogenes. In the Renaissance, the design of a building in plan involved the free use of the compass and straightedge to compose circular and polygonal schemes, followed by the superposition of a grid in order to establish scale.[52] By contrast, the grid in the examples here establishes the building's geometry through the practice of *diathesis*. Accordingly, the placement of elements on the axial intersections controls *symmetria* quantitatively through the integral modular relationships of parts to one another and to the entire outline of the stylobate or krepis, as in the ratios of Pytheos' plinths as 1:2 with the axial separations, 1:10 and 1:20 with the respective axial breadth and length of the peripteron, and 1:12 and 1:22 with the respective breadth and length of the krepis. At the same time, the grid makes *eurythmia* by establishing integral proportional ratios of breadth to length, as in the 1:2 peripteron, the 11:21 stylobate, and the 6:11 krepis, as well as in proportions shared between different dimensions like the 1:2 ratio of the widths of the naos and krepis, and the 4:5 ratio of the lengths of the naos and the peripteron. In this way, measure and harmony provide order and pleasing appearance to the building's plan.

This brief consideration of Ionian architecture in the Late Classical and Hellenistic periods points to the possibility that Greek ichnography was synonymous with grid-based approaches to design, and therefore limited to the Ionic order. In temples of the Doric order like the Parthenon, architects' insistence on placing triglyphs in the corners of friezes necessitated variation in the spaces that separate them, resulting in adjustments to the placements of the columns below that align axially with the triglyphs.[53] Whereas the design of Ionic temples may be "plan-driven" by a grid, then, the design of Doric temples is contingent on elements in the elevation and therefore incompatible with a regularly spaced grid.[54] Interestingly, Vitruvius asserts that it was precisely this problem that led Hermogenes to abandon the Doric order, and that Pytheos likewise rejected the Doric order "because the proportional system was inevitably faulty and inharmonious."[55] Yet despite such testimony, the fact is that the Doric order did not just vanish with its condemnation by these Ionian architects.[56] As demonstrated for Temple A at the Asklepieion at Kos (Figure 86), a Hellenistic temple of the Doric order could and did employ ichnography in its design process, responding to the challenge of axial contraction with an innovative geometry that was different from, but as simple as, the grid that underpins the layout of Ionic temples like those of Pytheos and Hermogenes.[57]

In fact, the temples of the Ionian tradition arguably cannot stand on their own as evidence for Greek ichnography and its principles as described by Vitruvius. One must not forget that the question of ichnography requires deft interpretation of extremely limited evidence: No examples of actual drawings survive and, although Vitruvius testifies to the existence and qualities of the practice in both direct and analogous ways, nowhere does he tell us who is responsible for its genesis and where it was employed.

Regarding the limited physical evidence cited in support of the application of reduced-scale drawing in the Ionian material, one must consider the small pedimental sketch discovered on the block within the temple of Athena Polias



83 Temple of Dionysos at Teos, Roman restoration of work by Hermogenes of third century B.C. Drawing author.

(Figure 80) with deep reservations. One cannot assume that a working drawing necessarily relates to the structure into which it is built as opposed to preserving an unrelated drawing from a reused block. In this case, the composition's size (ca. 47¼ cm) and the lines that relate a vertical accent to slightly different locations at the corners of the pediment are particularly troublesome. Rather than just suggesting a reduced-scale sketch for the temple's front, this drawing's size and features call to mind a simple funerary stele with its figural composition framed by piers, for which there are countless examples throughout the Greek world.

In addition, Vitruvius does not explicitly state that ichnography involved the drawing of grids. What Vitruvius does describe is Hermogenes' *eustyle* system of *symmetria* determined by the diameters and axial distances of the columns, along with four other classifications (pycnostyle, systyle, diastyle, and araeostyle) expressing differing magnitudes of separation given in modules equal to one column diameter.[58] A strongly skeptical view may hold that, even though the resulting scheme conforms to a square grid overlay in plan, it would not require a grid-based scale plan to create such a simple building. As such, the temples of Pytheos and Hermogenes would lack the same criterion for necessity assessed for the Parthenon in Chapter 1 of this book. On the contrary, one may make the case that ichnography is more necessary in more varied assemblages.[59]

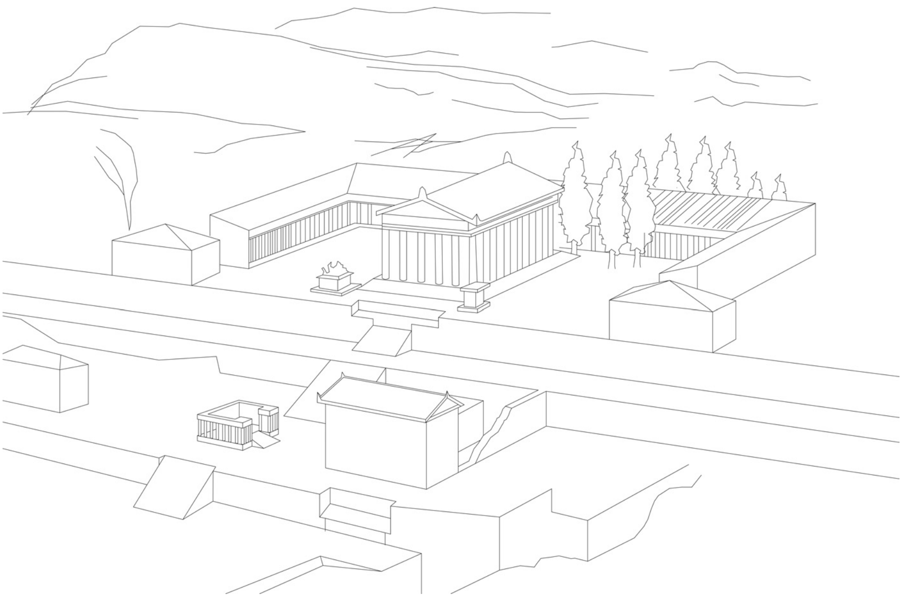
The reason is simple: Although grids are obviously geometrical in form, they are arithmetical in their modular and proportional relationships based on whole numbers. In place of drawings, therefore, they would be both conceivable and easily communicated through traditional written descriptions of dimensions (*syngraphai*) combined with models of individual elements (*paradeigmata*) like plinths and paving slabs.[60] Finally, the theoretical grid-based ichnographies of Pytheos and Hermogenes do not precisely parallel the overall unifying geometry of something like a circle and square found in Vitruvius' analogy of ichnography by way of the human form (Figure 79).

As for how Greek ichnographies might have related to actual building construction, I actually do not argue that ichnography ever replaced written descriptions and plastic models, with architects and masons suddenly appearing on site referencing blueprints of ground plans in the manner of the working drawings for entasis and column fluting at Didyma. Clearly the architect of such blueprints like those at Didyma at least imagined that his drawings would serve in the larger forms, details, and refinements that required uniform execution by several individual masons. Given the well-tested utility of verbal descriptions for setting the planar locations of such features, however, there is no reason to think that ichnographies need have always been made available to workers. Just as likely in many cases, ichnographies might have served only the architects who drew them during the working through of spatial relationships with the compass and straightedge.

During the period of their earliest introduction, in fact, many workers likely would have found such geometric *ideai* strange, if they understood how to work with them at all. This is not to insinuate that masons of any period are somehow limited when confronting abstract ideas. In comparison to the concrete provision of actual dimensions and full-scale models and drawings, rather, it is the ichnographies themselves that would have been limited. For one thing, a graphic idea like a grid or any other geometry underlying the positioning of a building's forms is of questionable relevance once construction begins. Furthermore, one cannot assume that Greek ichnographies always employed a uniform and integral ratio of scale and were both large enough and detailed enough to accommodate written specifications for individual dimensions. The constant need to relate abstracted aerial representations to parts or, worse, to calculate their dimensions based on ratio involves unfathomable steps for a culture of building that already had well-established procedures of working. Instead, architects who drew ichnographies likely converted them from graphic to written descriptions whose metric specifications were proportionally consistent with the magnitudes of the drawing. This conversion, in fact, may be preserved in the "Vitruvian man" passage itself, which describes textually the modular dimensions and proportions of the human form rather than illustrating them graphically. It should therefore come as little surprise that such *ideai* would not survive the construction of the buildings whose spatial order they determined.

The supposition that ichnography drove temple design in the Ionic tradition of Pytheos and Hermogenes must therefore rest on other factors. In the first place, round temple-like buildings and theaters with radial constructions that more clearly reflect the tools and procedures described in Aristophanes' *Birds* were well established by the Late Classical period, providing contemporaneous *comparanda* expressing the principles of ichnography found later in Vitruvius. The explicit presence of such practices thereby supports the notion designs grounded in similar principles observable in the work of Pytheos and Hermogenes likely occurred.

Secondly, there is the important issue of setting, a consideration that extends even beyond the observation that both the temples of Pytheos and Hermogenes are located within the "Hippodamian" orthogonal plans of Priene and Magnesia-on-the-Maeander. Built in the century after Aristophanes describes the plan of a city of the birds in terms of scale drawing, such city plans themselves may reflect graphic conceptions. At least in the case of Hermogenes' temple, moreover, there is the possible suggestion of an even clearer use of graphic design in the unification of diverse buildings.[61] Here, the Π-shaped, stoa-enclosed agora of the fourth century is oriented according to the cardinal directions in conformity with the town's layout of streets, whereas the temple is set at an oblique angle determined by the orientation of the Archaic temple that Hermogenes' building replaced. A single axis drawn through the center of the temple, altar, and



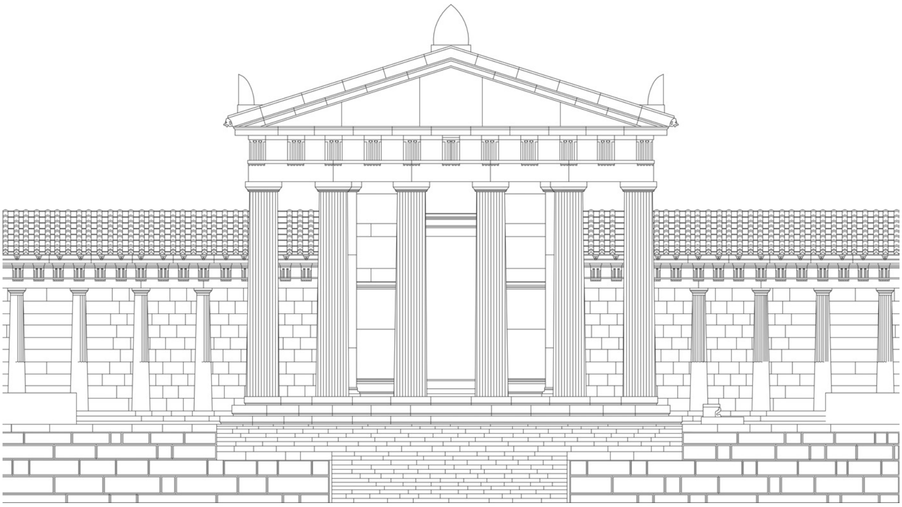
84 Asklepieion, Kos. Restored aerial view. Drawing author, adapted from P. Schazmann, in Schazmann 1932: Plate1.

propylon meets the center of the open space of the agora, and the quartering of the southern half of the agora establishes the location of the temple of Zeus.[62] The sense of spatial order thereby depends on a rather simple axial arrangement, suggesting Hermogenes' possibly influential role as a harbinger of the kind of approach to planning that would later characterize the urban architecture of Rome.[63]

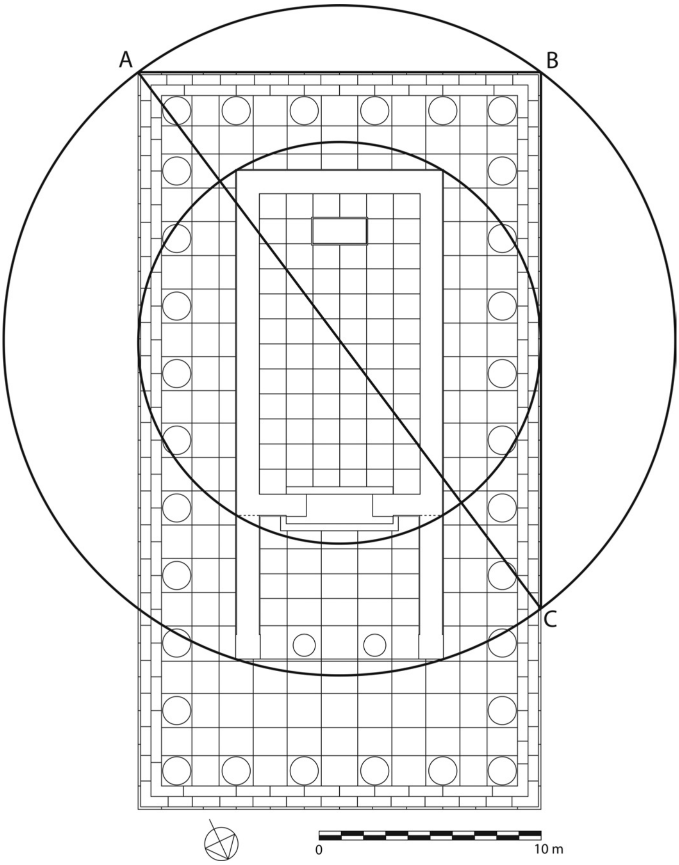
BEYOND HERMOGENES: FROM KOS TO ROME

The difficulty in applying the Late Classical and Hellenistic tradition of Ionic, grid-based ichnography to temples of the Doric order was matched by a lack of opportunities to do so. Although the Doric order continued to thrive in stoas throughout the Hellenistic period, from the fourth century onward, it is the Ionic order that dominates temple building. A rare Hellenistic era exception of a temple of the Doric order in a major pan-Hellenic sanctuary is Temple A at Kos, begun in ca. 170 (Figures 84–86).[64] Built on the highest of three terraces at the island's famous Asklepieion, Temple A dominates the medical sanctuary with its axial location at the apex of the grand ascent of the upper staircase.

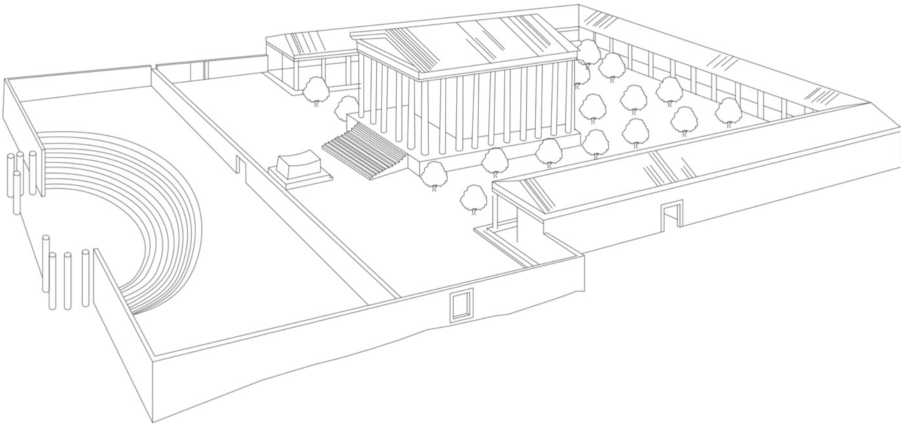
As a Doric temple lacking the Ionic order's readily available potential for a gridlike alignment in the manner described previously, a different approach to *taxis* and *diathesis* was necessary. The architect therefore created a plan with proportions of six by eleven, within which a 3:4:5 Pythagorean triangle *ABC* established the locations of the cella and pronaos according to the same 3:5 ratio



85 Upper Terrace with Temple A, Asklepieion, Kos. Begun ca. 170 B.C. Drawing author.



86 Temple A, Asklepieion, Kos. Begun ca. 170 B.C. Restored ground plan showing geometric underpinning of Pythagorean triangle *ABC*. Drawing author.

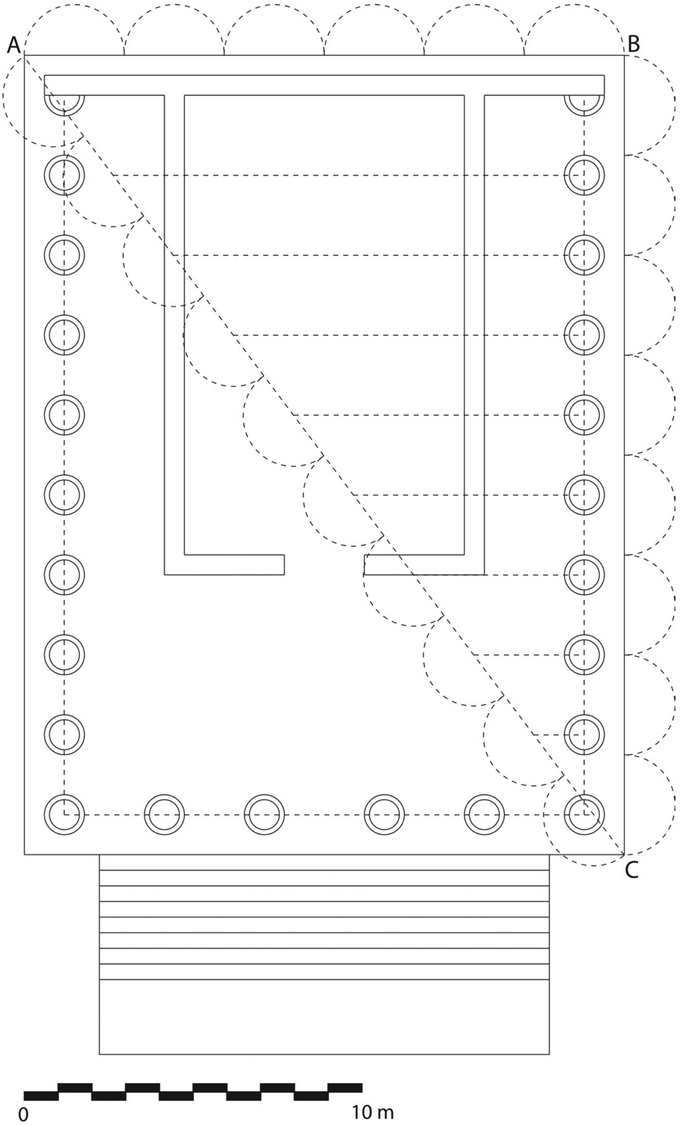


87 Sanctuary of Juno, Gabii, ca. 160 B.C. Restored aerial view. Drawing author, modified from M. Almagro-Gorbea, in *Gabii*: Figure 133.

of radii governing the cella and stylobate in the tholoi at Delphi (Figure 38) and later Rome (Figure 40).[65]

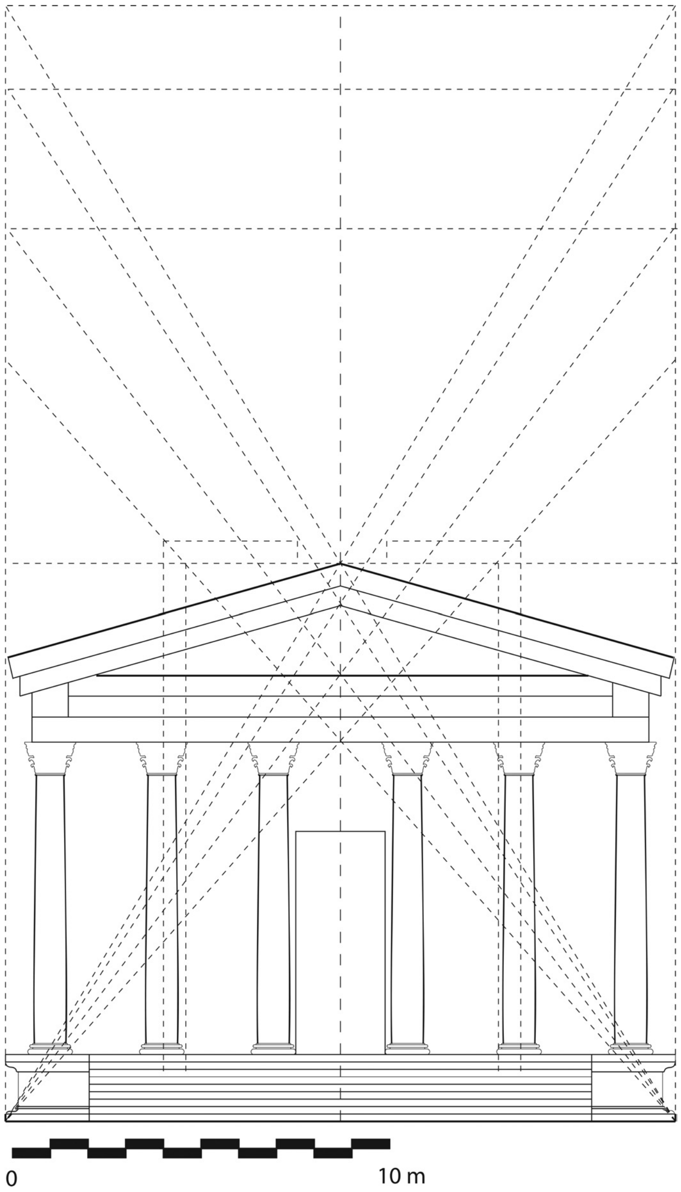
Beyond this geometric underpinning, a notable element of this building is its modular basis. The six-by-eleven temple and the 3:5 ratio of its circular *taxis* features an integral commensuration based on a module expressed by a part selected from the whole in the manner described by Vitruvius. In Temple A, this module is expressed by the length of the column-supported paving slab.[66] Accordingly, the total six-by-eleven dimensions of plan equals twelve-by-twenty-two modules, matching Pytheos' temple in Priene on its krepis.[67] Additionally, the 3:5 radii of its underpinning equal diameters of six and ten.[68] Like the maximum rise of entasis establishing the module for the blueprint for entasis at Didyma, then, the ground plan of Kos emerges from a modular 3:4:5 Pythagorean triangle.[69] In both cases, we confront a form whose geometric and modular underpinnings may not be obvious. On the other hand, both reflect habits of producing forms according to graphic ideas projected as whole-number relationships, just as the capital may emerge from the dimensions of a Pythagorean triangle (Figure 65) or its column's fluting from a circumferential measurement of twenty-four arris-framed flutes (Figure 57), or the construction for platform curvature from a 2:3 ratio of chord and radius (Figure 64).

Another feature at Kos heralds a development that was to be of great consequence for the history of architecture. In a way similar to Hermogenes' work at Magnesia-on-the-Maeander (Figures 23, 78), the ichnography of Temple A extends to the total environment, shaping the upper terrace as a complex dominated by a guiding central axis that anchors the temple within the frame of its Π-shaped stoa (Figures 84, 85). In a manner completely outside the tendency toward irregular and oblique relationships between self-contained buildings like those of the Athenian Akropolis, for example, the graphic conception of ichnography now establishes integrated compositions of buildings.



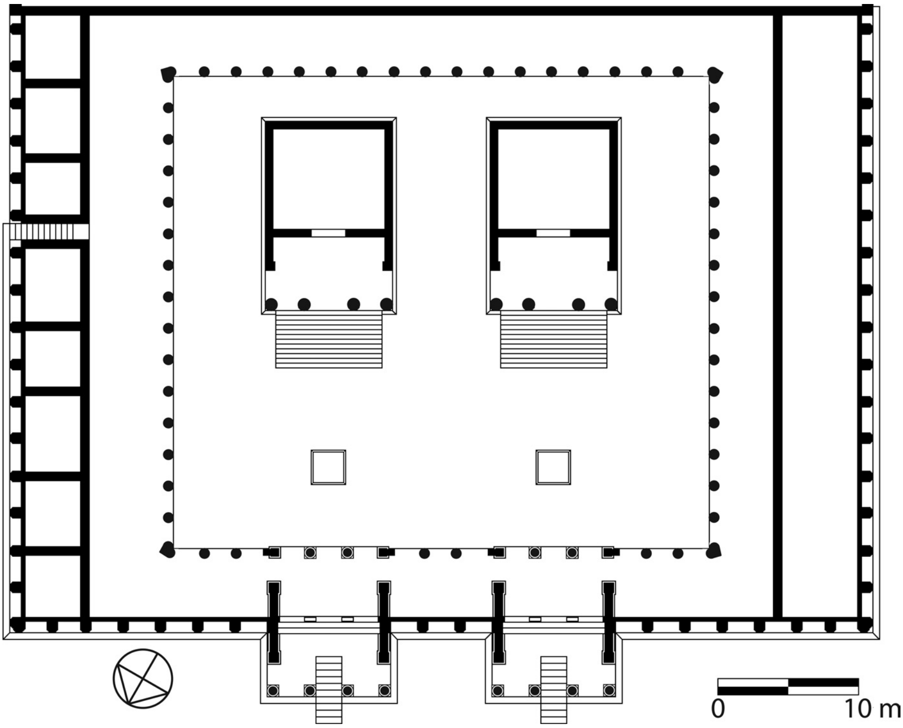
88 Temple of Juno, Gabii, ca. 160 B.C. Restored ground plan showing the use of the Pythagorean triangle in the generation of its design. Drawing author, modified from M. Almagro-Gorbea, in *Gabii*: Figure 2.

Contemporary with this complex at Kos was the Sanctuary of Juno at Gabii dedicated in ca. 160 (Figure 87), located some 26 km outside Rome along the Via Praenestina.[70] Here again, a Π-shaped portico frames an axial symmetrical arrangement, in this case raised above a theater-like seating arrangement that creates a terrace-like setting similar to that of the upper terrace complex at Kos (Figure 84).[71] Quite interestingly, the sanctuary's excavators have revealed that a 3:4:5 Pythagorean triangle underpins the design of the temple of the Corinthian order (Figure 88), with the ten equal divisions of the hypotenuse



89 Temple of Juno, Gabii. Illustration of unified conception of design in plan and restored elevation. Drawing author, modified from M. Almagro-Gorbea, in *Gabii*: Figure 4.

guiding the placements of the lateral columns in the manner of *taxis* and *diathesis*. Although this discovery long preceded the recent discovery of the 3:4:5 triangle in the Koan temple (Figure 86), the excavators at Gabii recognized this sanctuary's design as reflecting the conception of a Greek architect, going so far as to identify him as Hermodoros of Salamis,[72] the earliest known Greek architect in Rome. Whoever its architect may have been, the practice of ichnography

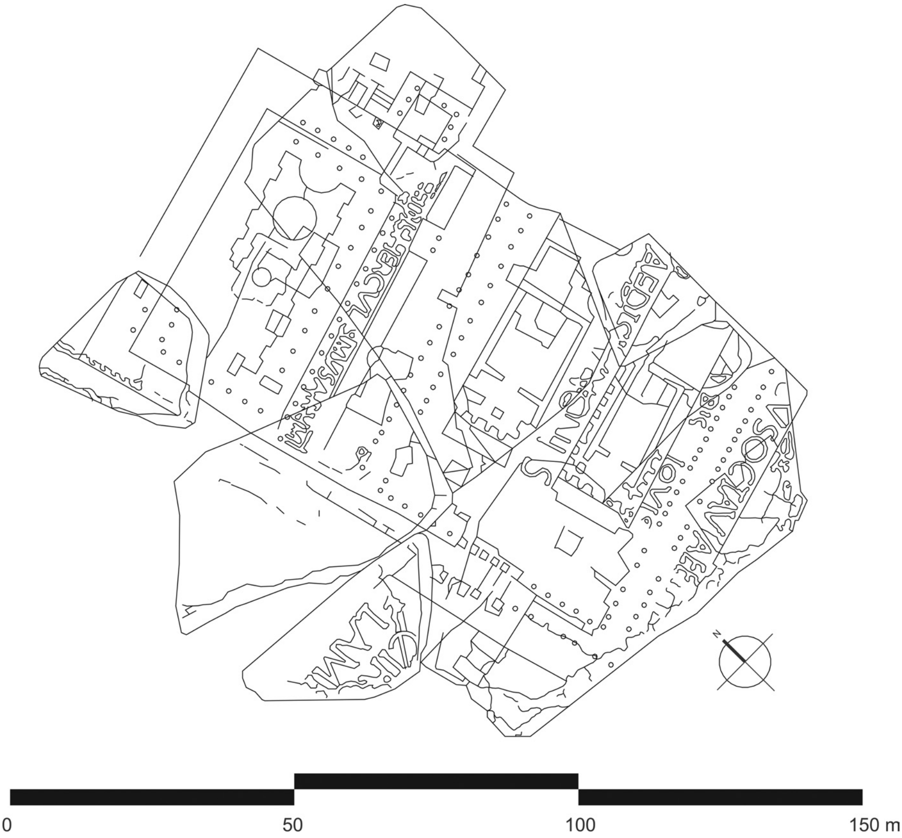


90 Sanctuary of Aphrodite (with temples of Aphrodite Pandemos and Pontia), Kos. Late third or early second century B.C. Restored ground plan. Drawing author, modified from V. Brighenti, in Morricone 1950: Figure 17.

brought from Greek traditions shaped both the cult building and its environment in a markedly Hellenizing way. According to its excavators' restoration of the Temple of Juno, the practices of drawing that guided its design were so systematic as to have unified its ichnography with its elevation (Figure 89), creating a complete expression of plan-driven design.

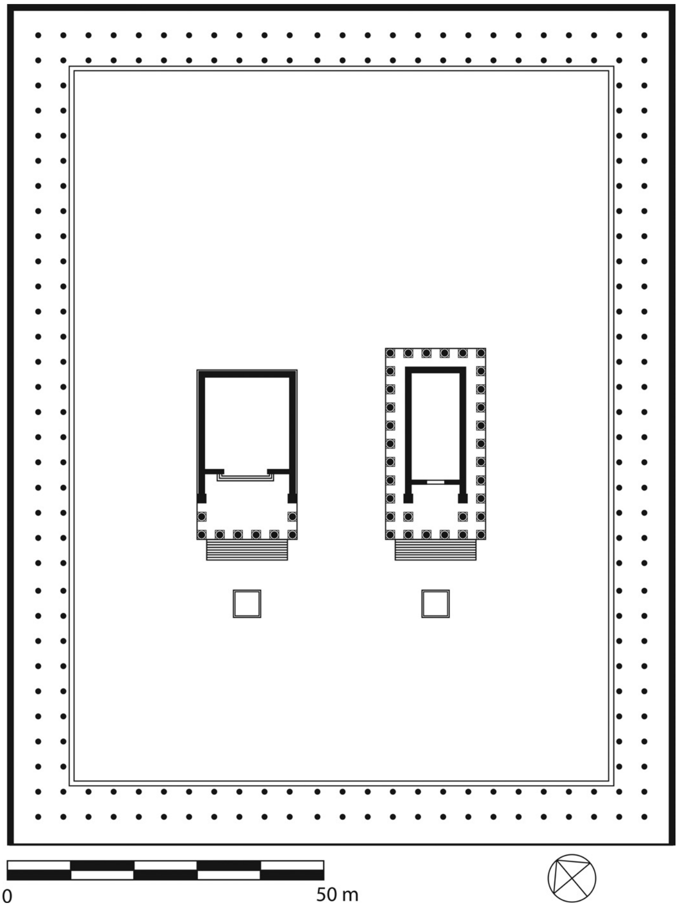
The character of the upper terrace complex of the Asklepieion at Kos had a local precedent. Next to the agora by the harbor survive the remains of the Sanctuary of Aphrodite of the late third or early second century (Figure 90). In an arrangement unique in the Greek world, two temples (dedicated to the cults of Aphrodite Pandemos and Aphrodite Pontia) within a porticoed enclosure axially align with square-shaped altars.[73]

As one finds in the correspondences between the Asklepieion at Kos and the Sanctuary of Juno at Gabii, a complex in Rome again follows on a Koan precursor. Based on excavations and the fragments of the Severan Marble Plan (Figure 91), the Porticus Metelli of the 140s is restored as portico-enclosed complex for two temples axially aligned with monumental square-shaped altars (Figure 92).[74] These temples include the Temple of Juno Regina and Jupiter Stator, the latter of which was the earliest all-marble temple in Rome



91 Severan Marble Plan fragments showing the Porticus Octaviae in Rome (Porticus Metelli, renamed and rebuilt under Augustus) enclosing its temples of Juno Regina and Jupiter Stator, and flanking the southern side of the Augustan era Porticus Philippi, with partial restoration. Drawing author.

(Velleius Paterculus 1.11.4–5), built by Hermodoros of Salamis (Vitruvius 3.2.5), the earliest known Greek architect working in Rome. It is important to stress that outside these two complexes in Kos and Rome (Figures 90, 92), I know of no other examples of this particular arrangement in the entirety of the classical world. The two connections shown here indicate an important legacy of ancient Greek ichnography: the graphic shaping of Rome's architectural fabric as a product of its Hellenization, in which symmetrical portico frames enclosed axially placed temples. The ultimate expression of this typological combination joined through a drawing board mentality is the Forum of Trajan, which completed the sequence of Imperial Fora that came to dominate the center of Rome (Figure 93).[75] Here one finds a shaping of environment made possible by the continuous practice of an abstract, disembodied way of seeing from above and outside the confines of natural vision, wherein the tools and methods of technical drawing can determine the layouts of vast spaces through planar conceptions.



92 Porticus Metelli (later Porticus Octaviae), Rome. After 146 B.C. Restored ground plan in accordance with fragments of the Severan Marble Plan and excavations. Drawing author.

VISION, DRAWING, AND BUILDING

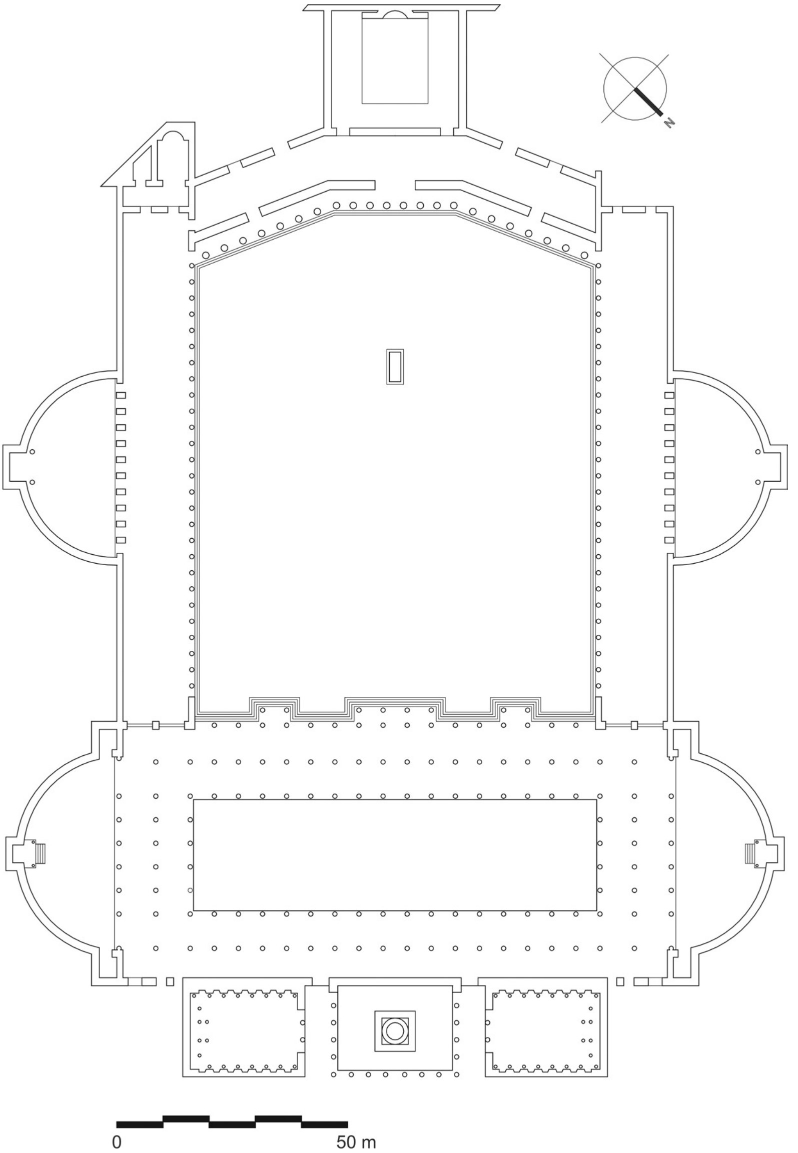
The parallel between the evolution of ancient drawing in the account offered here and that of the Renaissance merits recognition. In the High Middle Ages, architects were generally master craftsmen trained in masonry and carpentry.[76] Following Brunelleschi's reinvention of one-point linear perspective in the early fifteenth century, painters and sculptors as well as architects adopted his system of radial lines centered on a vanishing point.[77] Although perspective drawings were useful to architects in practice, Alberti's *On Building* framed a distinction between the drawings of painters and architects in a notably humanistic aesthetic justification that would have seemed alien to the traditional concerns of craftsmanship:

> The difference between the drawings of the painter and those of the architect is this: the former takes pains to emphasize the relief of objects in

> paintings with shading and diminishing lines and angles; the architect rejects shading, but takes his projections from the ground plan and, without altering the lines and by maintaining the true angles, reveals the extent and shape of each elevation and side – he is one who desires his work to be judged not by deceptive appearances but according to certain calculated standards. (*De re aedificatoria* 2.1)[78]

Whereas the painter deceives through value modeling and the composition of lines and angles represented in accordance with the foreshortening inherent in perspectival viewing (and therefore linear perspective), the true lines and angles of the architect's ichnographies and elevations are to be judged in accordance with predetermined principles and forms subjected to mathematical verification rather than embodied experience.[79] This notion is analogous with Ficino's contemporary Neoplatonic statement discussed in the introduction at the start of this book, in which the building imitates "the incorporeal Idea of the craftsman," and that "it is more for a certain incorporeal order rather than for its material that it (the building) is to be judged."[80] The statements of Alberti and Ficino resonate with Plato's privileging of "the true commensuration of beautiful forms" in sculpture as opposed to the "phantasms" of sculptors who alter proportions for the sake of appearance (*Sophist* 235d–236e). They are also in the spirit of Plato's celebration of the art of building for its tools of drawing and construction that ensure a precise sense of order verifiable through measurement (*Philebus* 56b-c). Finally, the stress on the incorporeal and "calculated standards" of Ficino and Alberti recall the Vitruvian man, where the body as an analogy for the temple is rendered as an ideal form through commensuration and the orthogonal and circular traces of the compass and straightedge. Here, the architect replaces the natural perspectival experience of a concrete human form with a flattened, graphic projection in which even the protruding toes share the same two-dimensional plane as a compass-drawn circle – a perfect geometry that circumscribes a theoretically centralized frontal image of the supine body from an abstract, aerial perspective directly above.

In theoretical writing, this difference and – at times – tension between the experiential and ontological concerns of representation can almost seem tantamount to a rejection of painting. Plato derides painters that intend their illusionistic effects as intrinsic virtues in their works (*Republic* 598b-c) and compares their imitations to one who may simply hold up a mirror to things in the world (596d-e).[81] This mirror analogy anticipates Brunelleschi's notably more sophisticated demonstration of his illusionistic system of one-point linear perspective as employed in his painting of the Florentine baptistery, known to us through the *Life of Brunelleschi* written by his follower Antonio Manetti.[82] In the panel of this painting, he pierced a peephole at the vanishing point

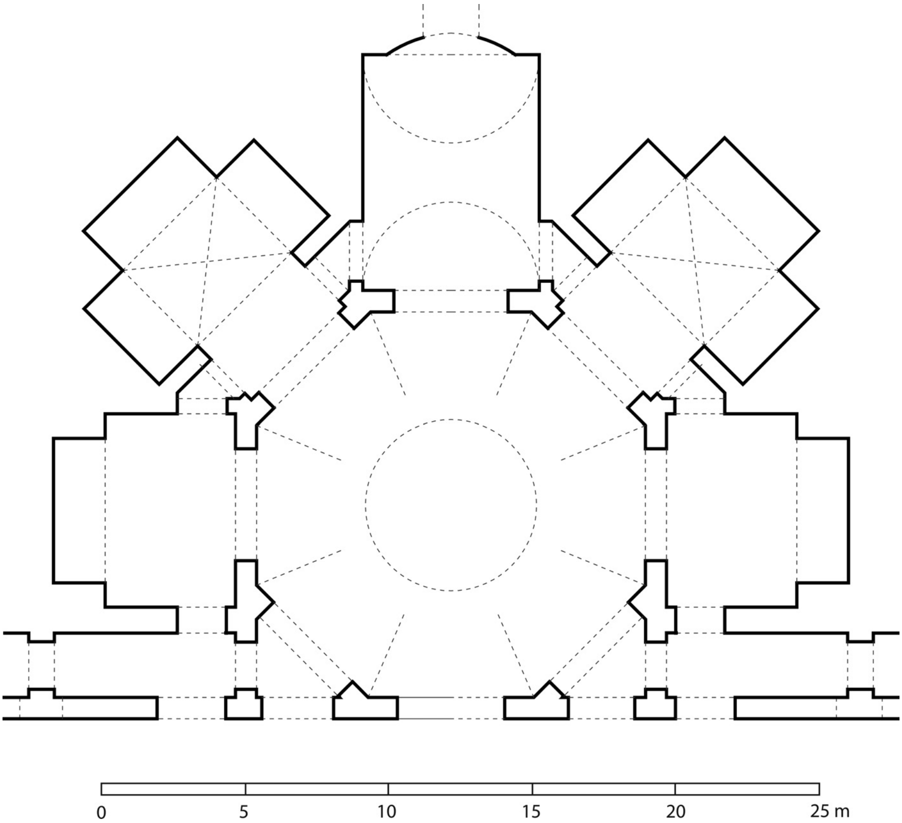


93 Forum of Trajan, Rome. A.D. early second century. Restored ground plan. Drawing author, modified from S. Rizzo, in Rizzo 2000: Plate 62.

through which the viewer was to look from the backside in the direction of the actual baptistery from the perspective from which the scene was painted. Between the baptistery and the painting, the viewer held at arm's length a mirror that reflected the painting so that, by moving the mirror away and back, he could verify the accuracy of the painter's representation, and hence the success of his perspectival system. By this means, Brunelleschi may be said to have unintentionally answered Plato's ancient criticism, penetrating to the instrumental rather than intrinsic value of pictorial illusionism by way of geometric principles.[83] In the theorization of these geometric principles in his *On Painting* dedicated to Brunelleschi, Alberti was one of a number of theorists (like Piero della Francesca, Leonardo, and Dürer) who elaborated upon the early *quattrocento* painter's contribution, just as Anaxagoras and Demokritos had elaborated upon the ancient Greek invention of linear perspective by Agatharkhos (Vitruvius 7.praef.11). Yet in the passage quoted above from Alberti's subsequent *On Building*, he abstracts the elements of line and angle underlying Brunelleschi's invention, elevating them to a level of calculable veracity beyond the concerns of deceptive appearance. In the orthographic projections of ichnography, it is the graphic vision of the pure idea rather than the painter's conceit for the optical experience of architectural space that is to guide the built form.

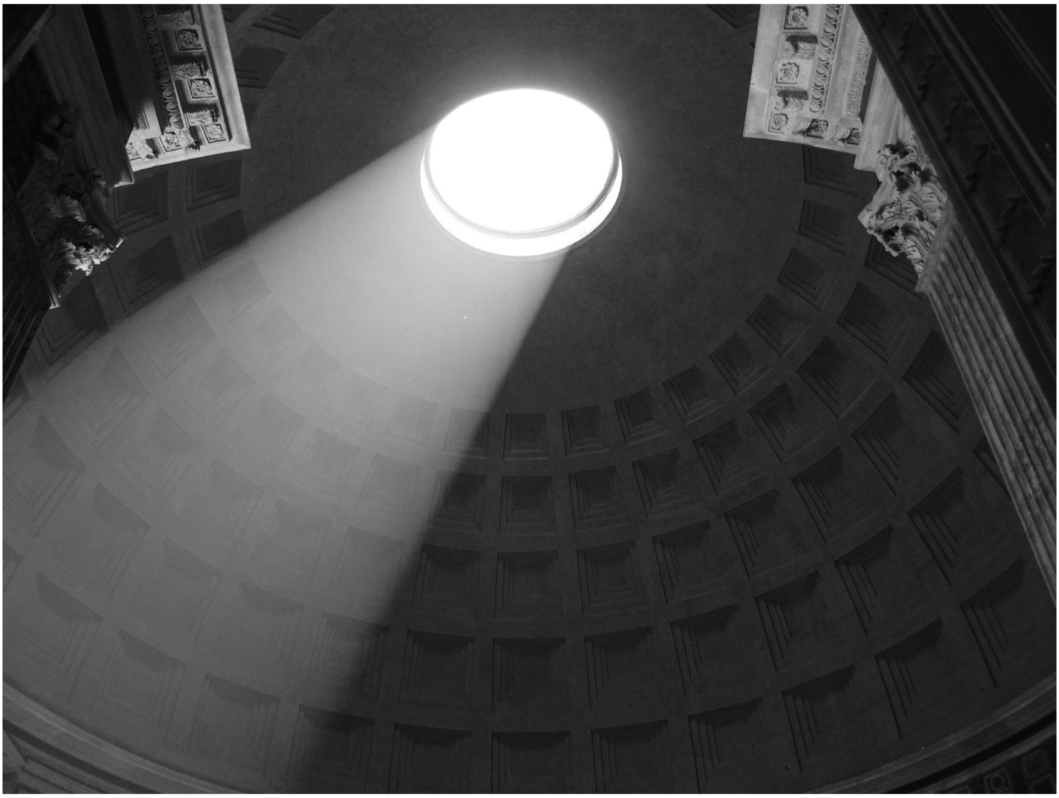
Grounded in literary rather than manual traditions, this humanistic sentiment reflects a growing separation of the Renaissance architect as intellectual from the traditions of craftsmanship. In a complicated way, however, this distancing from craftsmanship was shared by painters, and was therefore a point of comparison rather than contrast with figural artists.[84] Indeed, the intellectual foundations of artists from Brunelleschi to Leonardo, Michelangelo, and many others carried over to their own architectural projects. The development of linear perspective in painting thereby found a ready vehicle for entering into the design process of architecture, complementing the emulation of the ancient authority of Vitruvius who wrote that architecture is comprised of the *ideai* of linear perspective, ichnography, and elevation drawing. In the Greek theater of the Classical period, as I have argued previously, the invention of linear perspective in Greek painting similarly helped engender ichnography according to a distinctly architectural mode of vision, grounded in an ontological rather than experienced form. Although the written commentaries on the Greek art of building that preceded Vitruvius are completely lost, there can be little doubt of the influence that writer/practitioners from Pytheos onward must have had on the intellectualized conception of drawing reflected in the Roman writer's account of *architectura*. In both antiquity and the Renaissance, therefore, developments in painting along with theoretical discourse together likely contributed to the architect's way of seeing and shaping the world through the abstract mode of ichnography.

Beyond this rise of ichnography in Roman and Renaissance architecture, there is still another important legacy of the habits of drawing that originated in the Greek world. The circumferential approach hidden within the design process at Kos (Figure 86) and obvious in the Greek theater and other radial buildings would find its full expression in Roman buildings constructed in concrete – a material capable of shaping interior space all around and above according to the



94 Octagon of Nero's Golden House on the Esquiline Hill in Rome. A.D. 64–68. Ground plan. Drawing author, after B.M. Boyle, D. Scutt, R. Larason Guthrie, and D. Thorbeck, in MacDonald 1982: Plate 103.

circular and polygonal forms of the drawing board. By the time of Nero after the middle of the first century A.D., a building as remarkable as the octagon of his Golden House featured a radial conception with a centrifugal arrangement of rooms beaming out from the center, itself domed (Figure 94). This central room may be the Emperor's dining room described by Suetonius (*Nero* 31) as covered by a circular vault that revolved like the heavens. More celebrated yet, Hadrian's Pantheon (Figures 1, 95) was covered by a hemispherical dome articulated with a radial pattern of concentric coffers. Here, the spotlight from the single light source of the oculus slowly moves through the interior as the sun transverses the sky, bringing the revolutions of the cosmos into visual experience. Like Plato's diagrams of Daidalos, the envisioning of the cosmos by way of geometric drawing for the Golden House and the Pantheon was an expression more through craftsmanship than astronomy. In the ages following Vitruvius, however, the interest of both in the innate structure and mechanism of what can be seen in the universe could unite under the single entity of



95 Pantheon, Rome. View of dome's intrados. Photo author.

architecture. To convey this sense of order characterizing the entirety of space in the cosmos, the Pantheon's architect designed according to what was surely one of the oldest graphic expressions known to the art of building: the circular, radial form constructed for the fluting of a single column drum.

EXCURSUS

ENVISIONING COSMIC MECHANISM IN PLATO AND VITRUVIUS

The following is an excursus on Plato, Vitruvius, and preceding traditions of thought and craftsmanship going back to Anaximander and architects of the Archaic period. In addressing possible alternative justifications for the existence of ichnography before the Late Classical period, the analysis here supplements the exploration of buildings in Chapter 1. In setting buildings aside for philosophical texts and architectural theory, one may thoroughly enter into the premise at hand: That an interest in drawing among educated architects as intellectuals might have arisen in a literary background from abstract thought, and not just the practical requirements of planning. Along with a subsequent return to visual material in Chapter 2, this evaluation will elicit a nuanced view of connections between craftsmanship, intellectual traditions, and the production of knowledge in the Classical period. As the chapters of the main text elaborate, the genesis of ichnography, linear perspective, and characteristically Greek understandings of order in nature appear to owe a great deal to the design process of Greek architects in the craft of building, particularly in regards to the role of drawing in the creation of individual features at 1:1 scale that preceded reduced-scale drawing.

In carefully examining texts, furthermore, an encounter with additional concerns expressed in intellectual traditions changes the nature of questions asked in relation to the material evidence. Like the *ideai* that embody the principles of which *architectura* consists for Vitruvius, for Plato they connect unexpectedly to vision and the related graphic role of nature through representations of cosmic mechanism. The further kinship with Vitruvius' definition of architecture as comprising building, chronometry, and machines sets up an exploration of the role of vision in developments on linear perspective and ichnography in Chapters 2 and 3.

Beyond just providing a useful model for Plato's discussion of transcendent truth, *ideai* as architectural drawings may have already been understood to convey truth and spiritual value before Plato. In this regard, one may cite the use of number and geometry that underpins the side elevation and ground plan of the Archaic Temple of Athena at Paestum, with its Pythagorean triangles (Figure 29). According to Aristotle's scrupulous critique of Pythagorean thought (*Metaphysics* 985b23–986b8, 1090a21–1090a14), Pythagoreans posited numbers as the essence of all things, whether physical bodies or abstract concepts. Central to this all-important function of numbers are the harmonies expressed through integral ratio, as in music, where an octave occupies intervals between notes expressed as 2:1, 3:2, 4:3, and so on. On the basis of Aristotle (*Metaphysics* 1080b16), it has been convincingly suggested that for Pythagoreans, numbers represent not just arithmetical values, but rather concrete "unit-point-atoms" in space.[1] Seemingly in expression of this idea, in the fifth or fourth century, a Pythagorean named Eurytos used pebbles to compose schematic illustrations of men, horses, and other phenomena, in which numbers defined the true essence of the object represented.[2] This nexus of spatial representation, measure, beauty, and truth in demonstration of ideas not readily available to the senses is indeed consistent with the notion of a theoretical justification for ichnographies made for buildings of the fifth century. As discussed in Chapter 1, for example, in buildings like the Parthenon, the integral proportions of the completed temple's plan lay beyond optical perception.

Beyond the interesting possibilities for parallels in the *ideai* of both Plato and the craft of building introduced here so far, in the *Republic*, Plato addresses drawing directly. In one passage (529e–530a), he refers to the beautiful geometry of the diagrams of Daidalos, the mythological architect of the labyrinth, in a discussion of truth and models.[3] Here he characterizes these "most beautiful" drawings' relations like equals, doubles, and other commensurations as ultimately not conveying truth in itself,[4] which is not surprising given Plato's association of absolute truth with the intelligible rather than phenomenal realm. Yet before this discussion, he offers the *Republic*'s passage on the "Divided Line" (509d–511e), in which he suggests a more nuanced relationship between the visible and intelligible realms. Here he discusses geometric diagrams as visible images that the geometer may draw in pursuit of truth to be apprehended by the mind rather than the eye. In this way, geometric drawing is equated with understanding (διάνοια), which in the hierarchy of knowledge is second only to the rational part of the soul, itself the means of accessing truth in the intelligible realm of Ideas.

This point gains further clarification in the *Timaeus* (47a-b), where Plato explains the great value of vision as a gift from God that, when properly directed, in fact leads us to philosophy itself. In this set of passages, then, Plato appears to invite the reader into his text to explore the presence and significance of drawings like those of Daidalos. This invitation brings difficulties, but by following them through, one is better prepared to recognize the beginnings of the graphic construction of architectural space, which in my view first takes place in Athens during the fifth century.

First, one may ask whether the possible theoretical value of ichnography as truth in planar geometry and commensuration may be consistent with Greek architectural thought during the fifth century. Whereas our loss of Greek architectural treatises during this and all periods may to some degree justify our sole deferral to philosophical writing, one can at least bear in mind ancient testimony that directly addresses what Greek practitioners in the visual arts other than architecture had to say about related matters. Particularly useful in this regard may be statements relating the fifth-century thought of Polykleitos in his lost *Canon*, the celebrated treatise on sculpture, the title of which (Κᾶνον) was the term used for the kind of measuring rod used by architects.[5] As a work of prose focused on monumental figurative art and a single work (presumably the Doryphoros), the *Canon* appears to have been unprecedented.[6] On the other hand, the tradition of architectural treatises dates as far back as the first half of the sixth century, when, according to Vitruvius, Theodoros and Rhoikos wrote their commentary on the temple of Hera at Samos, and Khersiphron and Metagenes wrote about their work on the temple of Artemis at Ephesos (*De architectura* 7.praef.12–17). Similar commentaries on single works continue into the Classical period, with a work by Iktinos and a certain Karpion (a misreading or corruption of Kallikrates?) on the Parthenon in the fifth century,[7] as well as several others in the fourth century and the Hellenistic period.[8] Vitruvius makes explicit reference to *symmetria* or commensuration as a topic in several of these treatises, and when one recalls that Greek architects going back to Theodoros and Rhoikos also were commonly sculptors, the possibility arises that commensuration was a concern long shared by architects and sculptors alike.[9] As such, Polykleitos may very well have modeled his *Canon* on architectural treatises, suggesting the compelling possibility that concepts attributed to Polykleitos should also apply to coeval architects,[10] and therefore may be relevant to the present question concerning the possible philosophical value of *ideai* in the sense of architectural drawings.

Through this possible connection between architectural writing and Polykleitos, one can begin to see additional connections between the art of building and Plato. At the outset, it must be emphasized that evidence for what Polykleitos actually wrote is fragmentary and late, and the interpretations offered here are tenuous. Citing the *Canon* as an authority, in the second century A.D., the physician Galen justified the belief held by all philosophers and physicians that "beauty lies in the commensuration of the parts of the body" (κάλλος τοῦ σώματος ἐν τῇ τῶν μορίων συμμετρίᾳ, *On the Doctrines of Hippocrates and Plato* 5.48). If this statement accurately reflects Polykleitos' beliefs, then it would seem to foreshadow Plato's privileging of "the true commensuration (συμμετρία) of beautiful forms" (Plato *Sophokles* 235e).

To rest one's case here, however, would overlook some very solid recent interpretations of an important related statement that appears to clarify *how* commensuration engendered beauty for Polykleitos. According to a saying that Philon Mechanikos attributes directly to Polykleitos, "The good comes into being *para mikron* from many numbers" (τὸ γὰρ εὖ παρὰ μικρόν διὰ πολλῶν ἀριθμῶν γίγνεσθαι, Philon Mechanikos *On Artillery* 50.6).[11] Although various interpretations of the meaning of *para mikron* are possible,[12] it seems rather likely to convey the idea of small exceptions to the rule, as in slight divergences by way of corrections that minutely add to or take away from precise arithmetical relationships according to the sculptor's experience as a craftsman.[13]

Understood in this way, the strict resemblance to Plato's idealism begins to break down: Truth cannot be confined to a transcendental realm approachable only through a mimesis that rigidly follows the proportions of the perfect *idea*. Moreover, if one indeed accepts *para mikron* in this sense of an adjustment to the numbers, then the connection of Philon's quote with the mysticism of numbers in Pythagorean thought – a characteristic amenable to the idealist views later found in Plato – may be somewhat more problematic than it first appears.[14] After all, it is the numbers themselves that are being corrected in the process of making, and it would seem that this view represents a departure from the Pythagorean idea of number as the primary element of the universe, just as these same adjustments affirm the value of embodied experience at the expense of an abstract ideal.[15] In other words, the integral proportions of the Idea are not in themselves "the good," but rather a means in a process toward beauty that is not achieved until the sculptor makes small adjustments to them. As such, the parallel with idealism is far from clean. If parallels with later philosophy are needed, one may even read the spirit of Polykleitos' statement as foreshadowing not just Plato, but also Aristotle's description of the art of building (ἡ οἰκοδομική) as an art (τέχνη) that, like all arts, brings forth objects by way of *chance* (τύχη): "Art loves chance, and chance, art" (τέχνη τύχην ἔστερξε καὶ τύχη τέχνην, *Nicomachean Ethics* 6.4.5). Naturally, this admission of chance into the process of design is sympathetic to Polykleitos' sculpture that follows an arithmetical plan "except for a little" (*para mikron*) when skillful or intuitive adjustment from the rule makes for a more satisfying visual form.[16]

By no means do these considerations undermine the value that the *Canon* must have placed on integral commensuration in the process of design. Nor should they seriously imply any sort of proto-Aristotelian understanding of art on the part of Polykleitos. What they *do* suggest is that, despite the valid question of how fifth-century Greek art and its related theory may relate to contemporary and later philosophy, the differences in possible interpretations leave one on shaky ground when one actually tries to demonstrate such a connection. For reasons I explore further, however, Polykleitos' departure from pure number may not be sufficient cause for outright rejecting his association with Pythagorean thought.

For Plato, the distinction between what astronomers see and measure and the underlying truth of such optical apprehension and calculation is grasped through metaphor. Accordingly, we are to approach the astral bodies as models (παραδείγματα) of transcendent reality in the same manner that we would the geometric diagrams (διαγράμμασιν) of Daidalos or another craftsman (δημιουργός) or painter (γραφεύς).[17]

Like the astral bodies, the craftsman's geometric diagrams are models, but as such they are not simply models to be imitated in the built work. After all, this imitation is a problem for the making of things, as witnessed elsewhere in Plato's classification of the maker in the phenomenal realm with the potentially derogatory term "imitator" (μιμητής, *Republic* 597e).[18] Instead, the positive value of models lies in their almost synaptic character as objects both removed from truth and leading one toward truth by way of thought and reason (*Republic* 529d). On the one hand, from Plato's perspective, their clear separation from the Ideas in the intelligible realm may suggest that they should not merit their designation as *ideai* in Vitruvius (*De architectura* 1.2.1–4) in the sense of ichnography, elevation drawing or orthography, and perspective drawing. On the other hand, as models they are like the movements of the heavenly bodies in that they invite us toward an apprehension of truth. With the precise tools of measurement in the building trade (Plato *Philebus* 56b-c), furthermore, one may even read the suggestion that that trade's privileged position results from its scientific procedures that connect it back to truth specifically through the geometric plans as their models. Since Plato's only direct discussion of drawings is his reference to these plans, one must carefully consider this discussion if one is to properly explore the question of the *idea* as a shared term in both Plato and Vitruvius.

But first, in light of this possible connection between architecture and philosophy, the limitations of Plato's anachronistic relationship to Vitruvius and his distance from the concerns of architects and sculptors deserve emphasis. The separation of more than three centuries between Plato's death and the *Ten Books on Architecture*, as well as the lack of relevance of Plato's thought for those engaged in design and building, is readily apparent. The usefulness of Plato for this discussion is not one of how his philosophy influences contemporary, later, and much later architects and sculptors. Instead, the usefulness lies in the status of his metaphors as established facts in the experience of his readers that allows him to meaningfully manipulate such metaphors according to his own purposes. Plato clearly knew the activities of disciplines like geometry, astronomy, musical theory, building, sculpture, poetry, painting, and other arts. This knowledge allowed him to shape his discourse from the particulars of these disciplines. It is therefore more than a little possible that the beautiful and the good toward which Polykleitos' intuitive adjustments to numbers appears to have aimed may be related to the kind of thinking about craftsmanship that Plato drew on irrespective any specifically Pythagorean element.

At the same time, and in spite of any possible connections between architectural writing and the lost treatise of Polykleitos, one may also identify the usefulness and limitations of addressing our questions of architectural drawing with the help of figural sculpture. In terms of the relationship between the reduced-scale model and its full-scale imitation (as in Plato *Sophist* 235d), practices in the Classical sculptor's studio certainly suggest the possibility for parallel procedures in coeval architecture. This parallel may gain more clarity when one recalls the architectural context of marble sculpture, wherein the design of friezes and pediments suggests close interaction, if not collaboration, among Greek architects, masons, and sculptors.

A detailed consideration of sculptural praxis also reveals an important difference, however. Unlike the lack of necessity for reduced-scale drawings in Classical temple architecture as argued in Chapter 1, the creation of successful life-sized or large-scale sculpture in marble with any degree of naturalism and complexity of pose is simply implausible without models.[19] Using the additive process of working with clay at full scale allowed sculptors to establish the details of forms in isolated figures and larger groups able to fit as compositions into such a difficult frame as a pediment. In the imitation of these clay models in the subtractive method of chisel on stone, portable casts of parts of the models taken with negative plaster piece molds ensure workability in the task of copying when the full-scale models themselves are too heavy to move.

Yet the working through of pose and surface qualities in the full-scale model is itself impossible because of the structural limitation of clay or wax. A metal armature is needed. Of course, the composition of this armature itself presupposes a pose that the sculptor has already worked out in advance, which can only have taken place in reduced-scale models of the figures and their composition as a group. The supposed ignorance of reduced-scale models on the part of architects in the Classical period would therefore be difficult to support, and the argument against any equivalent practice for building must continue to rest solely on our perception of differences of tradition and necessity, like an Italian visitor who requests a fork in China.

Whereas there is certainly a strong case against ichnography's necessity in even such a relatively complex spatial composition as the Parthenon as analyzed in Chapter 1, Plato's reference to the diagrams of Daidalos opens at least a narrow fissure in the argument against tradition. Daidalos was a legendary sculptor as well as an architect.[20] As a sculptor, diagrams rather than plastic models would be of as little value as plastic models would be to Plato's purpose of addressing the geometric patterns of stars against the sky; it is the graphic and geometric quality of diagrams that evokes the architectural role of Daidalos

(*Republic* 529e–530a).[21] In response to the building trade's scientific accuracy and tools of precision celebrated in the *Philebus* (56b-c), in Chapter 1 I ask what it was that architects may have measured their buildings against. Possibly, Plato's reference to the diagrams of Daidalos may support a view that architectural drawings, and not just written specifications (*syngraphai*), established the measurements and proportional relationships to be followed in construction. What is not clear is whether such drawings would have been the reduced-scale *ideai* of Vitruvius (ichnography, orthography, and perspective) or the kind of working drawings for entasis and the fluting of column drums like those discovered by Haselberger at Didyma (Figure 33), or even something else entirely. Whatever the case (and for however little a casual formulation may be worth), it would seem that Daidalos would have gotten lost in his own labyrinth without the aid of ichnography.[22] If the *necessity* of ichnography cannot be demonstrated for the Classical period, Plato's discourse at least grounds our construction of the possible existence of the precursors of Vitruvius' *ideai* in the *traditions* of building several centuries prior.

This possibility invites further reflection on additional similarities between the narrative of making in Plato and Vitruvius. For Vitruvius, astronomy plays a very important role in architecture. In fact, Vitruvius folds astronomy into the very definition of architecture (*De architectura* 1.3.1), whose three parts include not only the art of building (*aedificatio*), but also the arts of chronometry (*gnomice*) and mechanics (*machinatio*). The entirety of Book 9 is dedicated to the measurement of time, in which one finds full chapters dedicated to the structure and patterns of the turning cosmos, the phases of the moon, the relationship between the path of the sun and the length of days and hours, the constellations, the contributions of great astronomers, the figure of the *analemma*, and sundials and water clocks.[23]

For Plato, the issue of chronometry is central to the activities of divine craftsman, whose creation of the heavenly bodies and their motions may be understood as the introduction of measures into the universe, with measure itself as the chief role of the Ideas. In other words, the divine craftsman is a maker of clocks and, thus imparted, the measure of time shapes the sense of order that underlies space.[24] For Vitruvius (9.1.2), it is the power of nature that has created the cosmos, but this is not Aristotle's natural power (φύσις) that brings forth phenomena through its own telic inner workings. Rather, it is nature's power as an architect that creates the cosmos as a machine in which wheels on a central axis revolve the heavenly bodies in a ceaseless circular motion above, around, and below the earth like the turning of a lathe.[25]

Interestingly, Vitruvius elsewhere complements this image of the machine as the underlying model for the shape and motion of the cosmos with an account of the cosmos as the model for machines (10.1.4). Vitruvius' division of architecture into three parts (building, chronometry, and machines), therefore, results in a corpus that is more unified than it may first appear. Nature designs the cosmos as an architect and, in building machines and relying on the circular motions of machines to erect buildings, architects build like nature. As to which of these creations occupies the exemplary position in the relationship between cosmology and building, Vitruvius is clear: "... from nature [our ancestors] took models and, imitating them, the divine led them into unfolding the comforts of life."[26]

For Vitruvius' passage here, the likely inspiration of Plato's divine craftsman has been noted elsewhere, and one may develop this connection along the lines of the imitation (*imitatio*, μίμησις) of models.[27] The intelligible and eternal mechanism of the cosmos that Vitruvius describes as the creation of nature as architect becomes visual in actual machines. Similarly, Plato (*Timaeus* 28c–29a) describes the maker (ποιητής) of the cosmos as a manufacturer (τεκταινόμενος) who creates the cosmos after a model or *paradeigma*. In this context, Plato describes two kinds of models (27d–28a): 1) the eternal kind, or that of eternal being and without having a becoming, and 2) the generated kind, or that of eternal becoming without being. He clarifies this distinction elsewhere (48e–49a) as the eternal, uniform, and intelligible Idea of the model (παραδείγματος εἶδος) and the merely visual, phenomenal copy of the model (μίμημα παραδείγματος). For Plato, the eternal models are the Ideas themselves, whereas generated models with an unfolding rather than eternal ontological status include the revolving cosmos of the divine craftsman himself and those diagrams of Daidalos or another craftsman or painter. In Plato's thinking, Vitruvius' ceaselessly revolving cosmos created by nature's power as architect would be a generated rather than eternal model. This philosophically based second-class status of phenomenal nature and the further removed status of the machines that imitate it are unlikely to have caused any anxiety for Vitruvius, however.

In the *Timaeus*, it is the wandering motion of the bodies of the planets that allows them to stand out against the uniformly repeated motions of the planetary orbits, thereby allowing the bodies to serve as markers – and therefore measures – of the numbers of time as given in the divine craftsman-architect's mechanism of the revolving cosmos (38c).[28] This knowledge comes from vision (ὄψις) that, when properly directed in the phenomenal realm of the cosmos, reveals number in the motions of the heavenly bodies, and that in turn is the origin of philosophy (*Timaeus* 47a-b). By implication, Plato does not simply mean that knowledge automatically results from visual experience. Rather, properly directed vision leads to reason and thought, which then allow for penetration of truth and the foundation of philosophy. Similarly in the *Republic*, "Reason and thought perceive these (true qualities like number), but not vision" (ἃ δὴ λόγῳ μὲν καὶ διανοίᾳ ληπτά, ὄψει δ᾽ οὔ, 529d). This seeming contradiction is actually a clarification that it is not the vision of the senses, but rather reason and thought as a different kind of seeing (and not an opposition to seeing) in which arithmetic enables the intellect "to see" (ἰδεῖν, *Republic* 524c). Both these sensory and intelligible approaches to seeing, then, come together in the turning, chronometric mechanism of the cosmos.

The appearance of this mechanism in both Plato and Vitruvius raises the possibility that, rather than simply the latter's dependence on the former, both the philosopher and the architect may have drawn on a discourse that antedated both. One possible indication of such an earlier discourse is testimony that in the sixth century, Anaximander of Miletos made and wrote about a sundial, a sphere of the cosmos, and a drawing of the circular outline (περίμετρον) of the earth and sea.[29] Interestingly, his cosmic sphere was supposedly a geocentric model featuring earth at its central axis in the form of a column drum, though our source for this architectural correlation is of the third century A.D. and may perhaps reflect later elaboration.[30] For his verbal description of the cosmos in prose and his representational models of it, recent scholarship has argued for Anaximander's collaboration with and dependence on the work of contemporary Ionian architects engaged in building and writing about the giant Archaic temples, starting the traditions of architectural theory with their early treatises.[31] Cosmological models remain important both for Plato in philosophy in the late Classical period and for Vitruvius in architectural theory at the close of the Hellenistic period, and one can only hypothesize a tradition of related tenets in the lost architectural discourse of Khersiphron and Metagenes, Theodoros and Rhoikos, Iktinos, Pytheos, Hermogenes, and others cited by Vitruvius.[32]

Plato, then, may be helpful as a possible reflection of the similarly shared ideas of Archaic architecture and philosophy that reach Vitruvius centuries later. Late Classical and Hellenistic architectural writers like Pytheos and Hermogenes may be Vitruvius' direct sources for *topoi* originating in the sixth and fifth centuries. As a rough contemporary of Pytheos, Plato may have taken influences from the same nexus of Archaic and Classical sources as this celebrated architect who, according to Vitruvius, could at least boast to have great depth of knowledge in many things (1.1.12). Still, although Pytheos may have read widely in several disciplines, there is no need to imagine Vitruvius studying Plato's descriptions of the cosmos or related philosophical discussions in works like the *Republic* or the *Timaeus*. Likewise, in spite of any sources that Hellenistic writers on architecture may have shared with contemporary philosophers, Plato's position outside of the continuing discourse on architecture should impart subtlety and care in how one interprets any resemblances that his writing may share with Vitruvius.

With this caveat in mind, one may approach Plato's reference to the diagrams of Daidalos with reserve. It may be tempting to read Plato's discussion as an evocation of what Greeks called *ideai* (ichnographies, orthographies, and perspective drawings), but Plato's reference to the beautiful geometry of these diagrams might have evoked something other than graphic representations of buildings. As previously suggested, the use of working drawings for the design of parts of buildings and their refinements (Figure 20) would seem to apply to what Plato describes no less than drawings of entire buildings at reduced scale. Moreover, the clear astronomical context of the passage may suggest a different possibility: That in light of the observable connections between classical architecture and astronomy preserved in Vitruvius, any architectural associations evoked by the name of Daidalos would not exclude the more straightforward interpretation that Plato references some kind of astronomical diagrams.

A consideration of the details of Plato's argument may support this view. In the first place, he employs an established metaphor between the shining stars and embroidery in a way that appears to emphasize a very specific point. In the *Iliad* (6.294–295), Athena is offered a *peplos* whose embroidery radiates like a star.[33] Similarly, Plato (529c–530a) describes the stars as embroidered on the sky, and as embroidery they are to be used as models in the manner of the diagrams of Daidalos or another craftsman or painter. In this way, the dialogue appears to rely on a rhetorical device to effectively pair the revolving heavenly bodies – the objects of concern to the astronomer – with an associated object in the realm of made, two-dimensional patterns that arrest the merely visible movements that cannot correspond to measurable real movements "in true number" (ἐν τῷ ἀληθινῷ ἀριθμῷ). This pairing sets up a comparison with a second pairing centered on the diagrams that, despite their beauty, cannot serve as examples of such truth in number, or "absolute truth as equal values, doubled values, or any such commensuration" (ὥς τὴν ἀλήθειαν ἐν αὐτοῖς ληψόμενον ἴσων ἢ διπλασίων ἢ ἄλλης τινὸς συμμετρίας). But with respect to the revolving astral bodies that pair with the weaving, what is the counterpart of the diagrams in this second pair? A possibility worth considering is that the diagrams of Daidalos may be drawings associated with the kind of revolving machines of the cosmos described by Vitruvius (10.1.4).

One's grasp of the way in which Plato's reference might have called to mind turning mechanisms requires detailed analysis of his comments in relation to specific qualities of "Presocratic machines" in both their character and function. In one possible interpretation, Anaximander's sphere of the cosmos featuring earth as a column drum in the center was itself a machine with revolving bodies, as in the cosmic model described by Vitruvius.[34] Although this scenario is tenable, an early philosophical written description of the cosmos as a turning machine would not really depend on a philosopher's construction of that machine. Instead, the machines created by contemporary architects and described in their commentaries were already at hand to serve as models for the philosophical envisioning of how the revolutions of the cosmos work. Khersiphron and Metagenes, the architects of the Archaic Artemision at Ephesos who left a commentary on the construction of that building, described the mechanisms that they invented in order to transport heavy stones from the quarry to the site of construction. These descriptions survive in Vitruvius (10.2.11–12). Like Anaximander's model that features the centrally located earth represented as a column drum,[35] and like Vitruvius' description of the cosmos as a constant revolution of the heavenly bodies around a central axis with the earth at its center, Khersiphron's mechanism is the shaft of a column fixed to a frame of timbers by pivots that allow the column to revolve ceaselessly. In this way, the column is transported precisely by its ingenious conversion into becoming a part of the vehicle that contains it, and in turn the load itself moves the machine through its own turning. Metagenes' mechanism modifies Khersiphron's design in order to transport the rectilinear blocks of the architrave, which he converts to axles by attaching wheels to either end that revolve like the wheels at the end of either axis above and below the earth in the cosmic model that Vitruvius describes. Again, the revolving load becomes a part of the vehicle that contains it – in this case, the axle that moves the machine.

As part of a discourse on building surviving from the Archaic period to Vitruvius, these Archaic machines may be helpful in approaching Plato's obscure passage on astronomy that leads to his comment about the diagrams of Daidalos. In directing the reader from the phenomenal realm of the stars to their transcendent reality, he writes that the visible cosmic bodies:

> fall far short of truth in real swiftness and in real slowness in true number and in all the true shapes (πᾶσι τοῖς ἀληθέσι σχῆμσι), carried as they are with respect to one another and in their turn carrying what is contained in them.[36]

In this difficult passage, Plato describes the difference between celestial phenomena and their true models in terms of the latter's character as vehicles that carry what is internal to them, referring to the Ideas of swiftness or slowness and numbers contained within the Ideas of the shapes (σχήματα).[37] These shapes themselves appear to be the models, the vehicles both carrying and carried. The subsequent comment about Daidalos may relate to this meaning and act as an especially appropriate, if obviously unintended, evocation of the architects who built and wrote about the Ephesian Artemision; exactly like Daidalos and Ikaros, Khersiphron and Metagenes were a father-and-son pairing who left Crete to build their creations elsewhere.[38]

Before characterizing how machines and Plato's diagrams of Daidalos might have related as models of cosmic mechanism, it is useful to consider how such models might relate to Plato's Ideas. Immediately following his statement about true models as vehicles and in reference to how we may access these true models, Plato writes, "Reason and thought perceive these, but not vision." This statement in turn immediately precedes his departure from the science of the astronomers who study visible motion to his proposed "real" astronomy that treats the night sky as a woven surface, a strategy that deflates its corporeal presence and arrests its motions in favor of an abstract, fixed image. Here, Plato inserts his comment about the diagrams of Daidalos or another craftsman or painter, equating them with the motions of the cosmos built by an unnamed craftsman (δημιουργός) that foreshadows the divine craftsman of the *Timaeus* who creates the cosmos after a model (28c–29a).

This equation should not imply that the divine craftsman builds his cosmos after diagrams that are the *ideai* of his cosmic machine, however. Nor can one readily see an elevation of the status of architectural *ideai* over the completed architectural or astronomical construction. Instead, something subtler is at work. In the *Timaeus* (47a-b), Plato states that properly directed vision leads to knowledge and yet derides those who lament the loss of their eyesight. In these stances there is no contradiction because true numbers – the intelligible Ideas of numbers – are grasped through philosophy, which is made possible by the observation of numbers as time in the mechanisms of the divine craftsman's cosmic clocks. Again, there are two kinds of *paradeigmata*: the generated models of becoming, and the eternal models of being that the generated models imitate, their uniform and intelligible Ideas (*Timaeus* 27d–28a, 48e–49a). Plato carefully distinguishes between the visible movements of the revolving vehicles and the real velocity in true numbers and the true shapes,[39] but these ideal numbers and shapes are not found in the geometry of the diagrams he cites. The revolving vehicles are the generated models of the cosmos, playing into a tradition that appears to go back to Anaximander, a tradition that conceivably suggested such mechanisms as models for Plato and his readers. The eternal models that are Plato's unique contribution to Greek philosophy are the Ideas for the generated models, and these Plato expresses as accessible only through a different kind of seeing. Understood in this way, both a diagram and a machine representing the cosmos would share the status of generated models, as would the associated pairing of embroidery and the stars. Each of these is distinct from the eternal models that serve the divine craftsman's construction of the cosmos.

In addition to this difference, it is difficult to find a parallel between the *ideai* as models for the divine craftsman's cosmos and the diagrams of Daidalos (or another craftsman or painter) as models for some kind of machine. If such a parallel were tenable, it would be helpful to have some indication that diagrams were a part of the production of machines in the Archaic or Classical periods. Without evidence, one cannot simply assume that diagrams would have served a prescriptive purpose in this context. Instead, this assumption would rise from reading Vitruvius with a modern perspective that associates the assemblage of machines according to illustrative diagrams, as one finds in the folios of Leonardo or many of today's toys.[40]

A close look at the relevant passages does not support such an interpretation. Plato writes that the diagrams of Daidalos contain commensurations like equals and doubles. From an engineering rather than philosophical point of view, such proportions in the diagrams for vehicles would serve a practical purpose as the basis for accuracy in the built mechanism, which in turn ensures the intended functionality of the device. In Vitruvius' account, a properly designed machine was not just one that revolved, but more specifically one that revolved in a way that covered distances within a limited time. He tells of a certain Paconius from recent memory who, in building a vehicle to transport a monumental statue base, did not follow the example of the architrave-vehicle of Metagenes that could reach the eight miles from quarry to construction site on schedule (*De architectura* 10.2.13). The result of Paconius' flawed design was a vehicle that swerved, overworking the oxen and slowing the journey until poor Paconius had wasted all his money. Vitruvius includes as many metric specifications and proportional relationships as are available to him from not only Paconius' recent lemon but also, remarkably, the vehicles of Khersiphron and Metagenes from half a millennium earlier.[41] Although these numbers indeed appear to serve a prescriptive purpose, it is important to note that Vitruvius omits any reference to illustrations of the mechanisms in his account, and there is therefore no indication that the treatise of Khersiphron and Metagenes included such diagrams. Like Vitruvius, more probably, these early architects relied on written descriptions with relevant metric and proportional specifications. In addition, even if there were such prescriptive diagrams for vehicles of transport, there is something unlikely about the notion of Plato being impressed by the beauty of their geometry.

The diagrams of Daidalos do not represent machines, but one's recognition of the element of *mechanism* that they relate to is important for understanding the world of made objects that Plato knew, as well as the transcendent truth of the universe that he describes. As visual phenomena, the diagrams stand as a suitable parallel to the cosmic mechanisms referred to in the same passage: The revolutions of the celestial bodies in their regular paths and, in the case of "wandering stars," repeated deviations as they make their way around the earth. Yet what makes this parallel especially interesting is the cultural background that, in a discussion of vision, would make a craftsman's diagrams a suitable parallel for such cosmic mechanisms. In considering the connections between vision, the craft of drawing, and graphic representations of cosmic mechanism, Chapter 2 explores these entities as a nexus in the development of linear perspective, ichnography, and constructions of order in the universe.

APPENDIX A

ANALYSIS OF THE DIMENSIONS OF THE BLUEPRINT FOR ENTASIS AT DIDYMA

See Chapter 3 and Figures 60, 62.

Measured from its central axis, the total radius of the blueprint's shaft (*f-i*) is ca. 1.01 m, with differences of only 1.5 mm between the widths of the top and bottom measurements. The top of the shaft where the arc intersects the chord measures 84.3 cm +/−0.1 cm (this portion of the drawing is not preserved, hence the uncertainty of .8429–8431 m for the restoration). Vertically, the drawing divides into the .3128 m base shown at 1:1 scale, and the 1.1857 m distance to the top of the drawing at d65 shown at 1:16 scale, resulting in a total height of 1.4985 m. The reduced-scale portion above the base measures 1.1232 m up to the level of the intersection of the arc and chord at d61a. At this level, the horizontal line does not conform to the regular intervals of dactyls of 1.85 cm, appearing instead 1.25 cm above d61, which Haselberger suggests may represent 2/3 of a single dactyl.[1] As Haselberger concludes, the drawn shaft's total height to this point is therefore 60 2/3 dactyls, roughly corresponding to the built shaft's height of 60 3/4 feet.[2]

The significance of this dimension becomes apparent in relation to the other dimensions within the drawing. As *b*, its relationship to *e* as the total height of the drawing from the bottom of the base to d65 is an integral 3:4 ratio: (1.123 m/3) × 4 = 1.4973 m, a negligible difference of −1.2 mm from 1.4985 m as measured in the drawing.

In turn, the total radius of the shaft *d* shares a 2:3 relationship with the total height *e*. For accuracy, *d* will be an average of the slight difference between its measurements at the bottom and top of the drawing: (1.008 + 1.0095 m) / 2 = 1.00875 m. With *e* as 1.4985 m (its actual measurement that equals its ideal measurement of 81 dactyls), (1.4985/3) × 2 = .999 m, a difference of −9.75 mm from 1.00875 m. Perhaps this difference may reflect the architect's addition of 1 dactyl to the entire lower *diameter* (and not radius) of the shaft, resulting in an intended measurement of 1.00825 m or $54\frac{1}{2}$ dactyls, a slight departure from the ideal 54 dactyls or .999 m. Admittedly, however, deviations of millimeters separating the actual drawing from the theoretical ratios proposed here render interpretation of intention extremely tenuous. Slight error in the process of drafting cannot be excluded. On this note, the false starts at *k* and *i′* in determining the drawn shaft's axis (and therefore all measurements of its radius) might remind one that drafting is not always a science, particularly in such large drawings executed vertically on a stone wall. For these reasons, the present analysis remains focused on the multitude of proportional correspondences with tolerances in the range of millimeters, rather than attempting to explain the motivations behind such narrow divergences.

Another integral ratio is the 3:4 relationship between *a* as the radius of the shaft at the terminus of the curvature at d61a and *b* as, again, the 1.123 m height to d61a: $(1.123 \text{ m}/4) \times 3 = 0.8423$ m, therefore in range of the measurement of 0.843 m $+/-0.1$ cm for this dimension in the drawing. As a 3:4 ratio with *b* (= 60 2/3 dactyls), the ideal measurement of this distance should be 45 1/2 dactyls, or .84175 m.

Taken together, these whole-number correspondences demonstrate the graphic rationale underlying the drawing in its entirety: the 3:4:5 Pythagorean triangle. At the core of the design is a 3:4:5 Pythagorean triangle *ABC* establishing the height and radius of the shaft at the level of the curvature's upper limit at d61a. In addition to this geometric definition, there is an important modular element as well: the arc's (*g*) maximum rise above the chord (*h*) is 4.65 cm, establishing the module that describes triangle *ABC* as commensuration of 18:24:30: $18 \times .0465 \text{ m} = .837$ m, a difference of 2–4 mm from .843 m $+/-0.1$ cm; $24 \times .0465 \text{ m} = 1.116$ m, a difference of -7 mm from 1.123 m.

APPENDIX B

ANALYSIS OF THE HYPOTHETICAL WORKING DRAWING FOR PLATFORM CURVATURE AT SEGESTA

See Chapter 3 and Figure 61.

If one may accept Haselberger's construction as the method for creating the euthyteria's curvature along its flanks of the temple at Segesta (Figure 61), one may well ask how the architect arrived at a maximum rise of .086 m. An attractive answer may emerge from the internal correspondences of the drawing itself. The maximum ordinate located above the center of the chord is 1.404 m from the center of the arc's diameter: 1.49 m − 0.086 m = 1.404 m.

Given the 1.49 m magnitude of the radius connecting the same center to the ends of the chord, the Pythagorean Theorem confirms Seybold's calculation of the length of the chord as ca. 1 m: with a hypotenuse of 1.49 m, the resulting sides are 1.404 m and .499 m, with the latter doubled to .998 m for the chord's full length. The chord therefore shares an integral 2:3 relationship with the radius of the arc: .998/2 = .499; .499 × 3 = 1.497 m. Despite the similarity of whole-number ratios, one can clearly see that the sagitta of .086 m does not establish modular relationships in the manner of the blueprint at Didyma; to be modular, the relationships would have to be integral, whereas .985 m/.0845 m = 11.166 m, and 1.478 m/.0845 m = 17.491 m. Instead, it is the eighteen equal divisions of the chord that correspond to the sequence of cross-marks on the stylobate, establishing a modular ratio of 18:27 in the drawing's chord and circle: .998 m/18 = .0554 m; .0554 × 27 = 1.496 m.

APPENDIX C

ANALYSIS OF THE HYPOTHETICAL WORKING DRAWING FOR PLATFORM CURVATURE IN THE PARTHENON

See Chapter 3 and Figure 63.

In the Parthenon, the long north flank of the stylobate has survived in a suitably well-preserved condition to allow for a detailed study of the measurements of its curvature. G.P. Stevens established seventeen coordinates documenting the incremental rise of the stylobate to a maximum rise of .103 m in the center of this dimension of 69.512 m long.[1] One minor complication in analyzing the curvature is that the two ends of the stylobate are not level, with the temple's northwest corner instead raised ca. 3 cm with respect to that of the southwest. As discussed in Chapter 1, there is some question as to whether this rise and that of the southwest corner (5 cm) represent inaccuracies of construction or deliberate "refinements of refinements" intended to correct an optically inferred convergence in the curved lines that would otherwise take place from the perspective of the Sacred Way (Figure 21). As a result, the theoretical baseline below the curvature is inclined with its slightly diagonal rise ca. 3 cm over the 69 m + distance from east to west. Seybold resolves this inconsistency by analyzing the ordinates in relation to the x-coordinates along a theoretically level baseline corresponding to the easternmost point at 0,0. This method in no way compromises the results because, in the end, an identification of the nature of the curvature (i.e., its optimal conic section) is not affected by this baseline's inclination of less than .03°.[2] Seybold's calculation identifies the north stylobate's curvature as an ellipse with a precise measurement of 2.141 m for its vertical semi-axis – that is, the radius of the lesser vertical dimension (as opposed to the greater horizontal dimension) of the ellipse. If the Parthenon used the same Didyma-related method for constructing curvature as that proposed for Segesta (Figure 61), this measurement of 2.141 m would represent the radius of the working drawing.

What has yet to be considered is the meaning of this radius in its relationship with the rise along the *y*-axis of the stylobate, which corresponds to the top of the semi-minor axis of the theoretical ellipse that defines the stylobate's curvature. This meaning emerges when we calculate the length of the theoretical working drawing's chord from which the architect established his ordinates *if* the architect considered this central rise (.1205 m) in relation to the easternmost part of the baseline (Figure 63).[3] The rationale for the intentionality of this measurement is the possibility that the architect indeed intended the higher level of the westernmost foundation (ca. 3 cm) as a "hyper-refinement"[4] – a possibility that would call into question the significance of the theoretical diagonal connecting this point with the lower northeastern corner of the stylobate.

The chord thus produced shares an integral 2:3 ratio with the radius, anticipating the identical ratio found in the proposed theoretical working drawing for curvature in the flanks at Segesta (Figure 64), demonstrated as follows: The rise of .1205 m subtracted from the radius of 2.141 m leaves a remainder of 2.02 m along the *y*-axis. Related to the radius as hypotenuse, one may calculate to find the length of half the chord a: $a^2 + 2.02^2 = 2.141^2$, resulting in the chord's value of $.711 \text{ m} \times 2 = 1.422$ m. Next, $(1.422 \text{ m}/2) \times 3 = 2.133$ m, a difference of −8 mm from 2.141 m, a tolerance of 0.6%.

This result should be regarded with skepticism. As discussed in Chapter 3, a possibility such as a pure coincidence in the analysis of Seybold's calculations remains open. I would therefore offer only the tentative suggestion that, in constructing the curvature on the flanks, the architect of the Parthenon (Iktinos?) may have proceeded in a very simple manner similar to the following (see Figure 63):

1) Draw a baseline *b* (= length of 1.422 m).
2) Establish a radius of 3:2 relationship with the baseline *b*.
3) Center compass for an arc intersecting the endpoints of baseline *b*.
4) Establish the westernmost point of the arc *w* corresponding to the higher level of the northwest corner of the stylobate (ca. 3 cm).
5) Draw adjusted (inclined) baseline *b′* from easternmost point *e* to *w*; bisect *e* and *w* with axis *a*.
6) Divide the drawing into equal sections (the twenty divisions in Figure 63 are hypothetical).
7) Divide the actual work into the same number of equal sections.
8) Transfer the vertical measurements at 1:1 scale from adjusted baseline *b′* to the arc at each of the divisions of the drawing to the equal number of divisions set at a greater horizontal distance in the actual work. These vertical limits will establish the unequal ordinates of the curvature according to a protraction of the main (horizontal) axis only.
9) Repeat for the southern flank of the temple with adjustment for westernmost point *w* at higher level (ca. 5 cm).

NOTES

Introduction: Challenges of Analysis and Interpretation

1 Vitruvius wrote his ten books between 35 and 20 B.C.; see Fleury 1990: xvi–xxiv; Fleury 1994: 67–68; Howe and Rowland 1999: 1, 3; Wilson Jones 2000a: 34. Following Brunelleschi's development of one-point linear perspective in the early fifteenth century, Alberti theorized it according to geometric principles in his *On Painting* of ca. 1435; see Lindberg 1976: 147–149. For a comparison between reduced-scale architectural drawing in the Renaissance and antiquity, see Chapter 4 of this book. For architectural drawing in the Middle Ages and Renaissance, see Ackerman 2002 and earlier studies cited. In a recent study of the drawings of Bramante and others, Huppert 2009 argues that perspective played an important role in the design process of new St. Peter's despite the privileging of orthography on the part of Alberti and Raphael, whose rejection of linear perspective in the service of architecture has tended to mislead modern scholarship's assumption of the limited use of the system in the Renaissance outside of painting and relief sculpture. For Alberti's relevant testimony in his *On Building* of ca. 1450, see Rykwert, Leach, and Tavenor 1988: 34. For Raphael's, see Di Teodoro 1994: esp. 123.

2 According to Suetonius' discussion of Julius Caesar in Gaul, Caesar concealed his intention to advance toward Rome by feigning normalcy and inspecting a plan, *forma*, of a gladiatorial school (*Divine Julius* 31). The context of the ruse clearly suggests the normalcy of inspecting such plans. Essential to the purpose of this particular *forma* is the future participle *aedificaturus*, and thereby consistent with the metaphorical usage by Cicero in a letter to Caelius Rufus (*Epistulae ad familiares* 2.8), and again in Cicero *Epistulae ad Quintum fratrem* 2.5.3. See also n. 24 in this chapter. Properly speaking, however, none of these passages necessarily refer to ground plans. Vitruvius' Greek term for a reduced-scale ground plan is *ichnographia*, where its meaning is clear (*De architectura* 1.2.2). As given in the context of the passages of Suetonius and Cicero, we should understand *forma* in the more general sense of architectural drawings used in the planning process, be they ground plans, elevations, perspectives, sections, or whatever.

3 See de Franciscis 1983: Plate I.3. See also the relatively unknown elevation of an arcade found at Pola, in which circumferential intersections find the axes of the

supporting piers: Gnirs 1915: 37, Figure 17; Haselberger 1997: Figure 7. As Haselberger also observes (n. 15), the modern scale bar in the original publication's illustration is approximately 50 percent too small. Like examples of full-size (rather than scale) drawings, this drawing survives because it was incised in stone, but Roman examples executed on perishable surfaces might have been common, as suggested by the literary evidence (see previous note). For surviving full-size drawings of the Hellenistic and Roman periods that were executed on-site to work out details, see Wilson Jones 2000b: 56–57, 206–207. Senseney 2011 examines drawing and the planning process in Roman architecture.

4 See Wilson Jones 2000a: 50, citing research on neurological and cognitive behavior associated with the act of drawing. I believe this view is implicit in the earlier assessment of MacDonald 1982: 5, 167–170. Taylor 2003 recognizes the importance of Roman architectural drawing by devoting much of chapter 1 of his study on the process of Roman construction to the production of drawings.

5 See, for example, Ward-Perkins 1981: 100–101.

6 Of course, this suggestion is not inconsistent with the long-accepted notion that Roman builders discovered the properties of *opus caementicium* gradually throughout the Late Republican period in utilitarian contexts like warehouses and engineering works. Rather, it merely posits a motivation to employ that material in the way we find it in important projects like the Domus Aurea, Domus Flavia, Pantheon, etc. For the dependency of mature Roman concrete architecture on utilitarian antecedents, see MacDonald 1982: 1–7.

7 For the functions of ancient architectural drawings as models, documentations of built structures, and votives, see Haselberger 1997: 83–89.

8 For *parti*, see Johnson 1994: 239–240, 338. For the development of *parti* since its early origins in the Ecole des Beaux-Arts, see Van Zanten 1977. A particularly fascinating study connecting Beaux-Arts traditions of architectural drawing on the part of American architects with principles of design observed in ancient monuments (among those of later eras) is Yegül 1991.

9 This text was at first issued serially and appeared as an integrated volume in 1897 with approximately 2,000 (!) illustrations.

10 Ausonius (*Mosella* 306–309), Strabo (9.1.12, 9.12.16), and Pausanias (8.41.9) mention only Iktinos as the architect of the Parthenon, and not Kallikrates whom Plutarch mentions (*Pericles* 13). The temple's designer therefore was likely Iktinos; see Coulton 1984: 43; Hurwit 1999: 166; Gruben 2001: 173; Korres 2001a: 340; Korres 2001b: 391; Schneider and Höcker 2001: 118; Barletta 2005: 95; Haselberger 2005: 148 n. 10. For the sources and arguments concerning Iktinos, Kallikrates, and Karpion (mentioned by Vitruvius *De architectura* 7.praef. 12 as Iktinos' coauthor of a commentary on the Parthenon), see also Carpenter 1970; McCredie 1979; Svenson-Evers 1996: 157–236; Gruben 2001: 185–186; Korres 2001a, 2001b, 2001c; Barletta 2005: 88–95.

11 Lynch 1960.

12 MacDonald 1986; Favro 1993; Yegül 1994; Favro 1996.

13 Favro 1996. See also Favro 1993. For an interesting discussion of Virtual Reality models of ancient Rome, representation, recreation, viewer experience, and visuality, see Favro 2006. For an experiential analysis of the street experience of Ephesus, see Yegül 1994.

14 The identification of the Roman marble copy in the Museo Nazionale in Rome with Myron's original is made possible by the exactness of Lucian's description (*Philopseudes* 18). For analysis of the copy and its possible relationship to the lost original, see Ridgeway 1970: 84–85.

15 The work was likely a votive dedicated in connection with athletic contests. For the Hellenistic rather Classical date on stylistic and iconographic grounds, see Kallipolitis 1972. For dating of the late second to first centuries B.C. based on pottery from the ship wreckage, see Wünsche 1979: 105–107. Hemmingway 2004: 83–114 argues for a date in the second half of the second century B.C. For analysis, see also Stewart 1990: 225 with Figs. 815–816.

16 The frontal view presented in Figure 30 of Hemmingway 2004 may be taken from too high an angle, however. The full effect is best appreciated at standing eye level in person.

17 Pollitt 1986: 149. See also Stewart 1990: 225 with Figs. 819–820 (copies in Museo Nazionale, Rome and Louvre, Paris); Ridgway 1990: 329 with Plate 166 (copy in the Villa Borghese, Rome); Stewart 1996: 228–230; Stewart 2006: 175. At present, restrictions of crowd control in the display of the copy at the Villa Borghese do not permit the kind of viewing described here. The copies may represent the *Hermaphroditus nobilis* by the second-century B.C. sculptor Polykles referred to by Pliny (*Natural History* 34.80).

18 Plato *Republic* 346d, *Gorgias* 514b, *Charmides* 170c; Aristotle *Nicomachean Ethics* 6.4.4.

19 Before Vitruvius, *architectura* appears in Cicero *De officio* 1.42.151. The Greek equivalent of *architectura*, ἀρχιτεκτονία, dates to the second century A.D. and is clearly derivative; Liddel, Scott, and Jones 1940: s.v. See also Greenhalgh 1974. For a discussion of the nature and role of the *architekton* and relevant primary sources, see Coulton 1977: 15–29.

20 In addition to the Latin *decor* (referring to practical considerations of tradition, function, and natural siting), he names *oikonomia* (codices: *oeconomia*, the natural and financial resources needed for the work), *taxis* (ordering), *diathesis* (design or placement), *eurythmia* (pleasing form), and *symmetria* (modular commensuration). Lauter (1986: 30–31) speculates that Vitruvius here turns to architectural theory of the fourth century.

21 See Pollitt 1995.

22 For this process, see Bluemel 1969: 34–43.

23 Codices: *ideae*: *Species dispositionis, quae graece dicuntur ideae, sunt hae: ichnographia, orthographia, scaenographia* (*De architectura* 1.2.2).

24 Haselberger 1997: 92–94; Senseney 2007: 560; Senseney 2009: 44–45; Senseney and Finn 2010: 88. Vitruvius' translation of *ideai* into *species* (from *specio*, "I see"), preserves this connection to vision. The same term appears in Aulus Gellius (*Noctes Atticae* 19.10.2-3).

25 Da principio lo Architettore la ragione e quasi Idea dello edificio nello animo suo concepe; dipoi fabrica la casa (secondo che e' può) tale, quale nel pensiero dispose. Chi negherà la case essere corpo? Et questa essere molto simile alla incorporale Idea dello artifice, a la cui similitudine fù fatta? Certamente per un certo ordine incorporale più tosto che per la material simile si debbe giudicare. Marsiglio Ficino, *Sopra lo amore o ver convito di Platone* (Florence 1544), Or. V, ch. 3–6: 94–95. Original text quoted from Panofsky 1968: 136–137, English translation mine. For connections between Neoplatonism and architectural drawing during the Renaissance with a specific focus on the *Hypnerotomachia Poliphili* published in Venice in 1499, see Moore 2010.

26 Heidegger 1967: 118–121. For discussion, see Wigley 1993: 37–41.

27 Diodoros Sikeliotes 1.985–9. See Pollitt 1974: 28–29; Bianchi-Bandinelli 1956. Elsewhere, in the *Philebus* (56b-c), Plato directly addresses the art of building's value as

a pursuit whose tools of measurement allow for precision. For analysis, see Chapter 1 of this book.

28 For this view, see Davis 1979; Davis 1989: 106 and 225 n. 1; and Bianchi 1997: 37 44 n. 38 for additional views and bibliography, including explorations of whether Plato may have visited Egypt. For a view on Plato's indebtedness to Egyptian culture, see Bernal 1987: 103–109.

29 See Mohr 2005: xv for comments on the recent "borification of Greek philosophy."

30 Nightingale 2004: 7–11, 111. On the difficulties of assessing Plato's views on art in particular through the lens of Nietzsche, see Janaway 1995: 190–191.

31 Nightingale 2004: 100–107, 113–115.

32 For discussion of the relationship between *theoria* and *thauma*, see McEwen 1993: 20–25; Nightingale 2004: 253–268.

33 Nightingale 2004: 8–11, 99–100, 111. The partial and perspectival views of the human philosopher are to be distinguished from the ideal philosopher who does not exist in the worldly realm; see Nightingale 2004: 98–99. On the motivations of personal, human potential and political observations that lead the philosopher to return to the cave, see Sheppard 2009: 119–124.

34 For experiential analyses in Roman architecture, see MacDonald 1986; Yegül 1994; Favro 1996. For a detailed study of the relationship between architecture and ritual at the Didymaion (as well as at the oracular temple at Klaros), see Guichard 2005.

35 Pollitt 1986: 149.

36 Pollitt 1986: 149. This is one of several possible interpretations Pollitt offers.

37 For relevant passages in Plato and expanded discussion of the following, see Chapter 1 and Excursus in this book.

38 For *Yin* and *Yang*, see commentary of J. Needleman in Feng and English 1989: xxii–xxviii.

39 See Needleman in Feng and English 1989: x–xiv.

40 Sokrates emphasizes that the Idea of the Good is the final experience of the journey (*Republic* 517b).

41 For *theoroi* and *theoria*, see Goldhill 2000: 166–167, 168.

42 Nightingale 2004: 40–93.

43 εἴ τις ἐντύχοι ὑπὸ Δαιδάλου ἤ τινος ἄλλου δημιουργοῦ ἤ γραφέως διαφερόντως γεγπραμμένοις καὶ ἐκπεπονημένοις διαγράμμασιν (529e).

44 "Roman Architectural Revolution" was coined by Ward-Perkins 1981: 97–120, akin to the "New Architecture" of MacDonald 1982: 167–183. Valuable recent studies of Roman concrete construction include Wilson Jones 2000a; Ball 2003; Lancaster 2005.

45 Translation of Rowland 1999: 24. Importantly, see also Thomas Howe's illustration of the graphic principles shared between the many disciplines in Howe and Rowland 1999: 144, Figure 6.

46 On this point, see Wallace-Hadrill 2008: 147.

47 Third century: Herakleides Kritikos 1.1. Roman period: Strabo 9.1.16; Plutarch *Pericles* 13.4; Pausanias 1.24.5–7, 8.41.9; see Beard 2002: 23–28.

48 On the range of emotional reactions by visitors to the Parthenon in recent centuries and decades, see Beard 2002: 1–12. For the reception of the Parthenon from antiquity to the present, see Kondaratos 1994.

Chapter One. The Ideas of Architecture

1 I distinguish between architectural design process and engineering, which worked according to a different set of concerns where reduced-scale drawing was helpful or even necessary, as in the tunnel of Eupalinos at Samos dating to the sixth century.

Here, a reduced-scale horizontal section of the mountain would have aided the establishment of a meeting point of the two portions of the tunnel running from the north and south; see Kienast 1977, 1984, 1986/7, 1995, 2004. For arguments against reduced-scale drawing in the architectural design process, see Coulton 1977: 53–73, 1985. For detailed criticism against authors who attempt to argue for reduced-scale, geometrically based plans that underlie the Parthenon's design, see Korres 1994: 79–80. Conversely, other studies are vocal in their advocacy of scale drawings during the Archaic and Classical periods; for example, Petronotis 1972; Dinsmoor 1985. In his recent book on the Propylaia, Dinsmoor (2003: 4) is explicit in proposing Mnesikles' presentation of a reduced-scale ground plan in the planning process for his celebrated building of 437–432. An opposing view was long ago expressed, as in Bundgaard's presentation of Mnesikles as an assembler of simple forms who would not have "planned his building in the modern way, i.e. by drawing an accurate geometric projection of it on a reduced scale" (Bundgaard 1957: 91). Riemann 1959: 318–319 objected that Mnesikles was certainly an artist and, given the sophistication of design in the Propylaia, he must have produced drawings.

2 Vitruvius provides the only clear discussion of architectural drawing in the classical world; see Frézouls 1985.

3 See especially the criticism of Riemann by Mertens 1984a: 175–176.

4 For example, the width of the colonnade axis, stylobate, or euthynteria and the height of the entablature including or excluding the cornice.

5 Mertens 1984b: 137, 144–145. For a view favoring the importance of drawing in conjunction with such whole-number relationships in the design process of buildings, complexes, and cities during the Hellenistic period, see Hoepfner 1984, which does not address the specific issue of reduced scale.

6 These rational correspondences are found as early as the Archaic Temple of Hera I at Paestum; see Mertens 1993: 80–87, 2006: 143. For similar though arguably more sophisticated numerical schemes at work in the slightly later Archaic Temple of Athena at Paestum, see Kayser 1958: 49–60; Holloway 1966: 60–64, 1973: 64–68; Nabers and Ford Wiltshire 1980. For full analysis of the temples at Segesta and Himera (large temple), the Temple of Athena at Syracuse, Temple A at Selinut, and the temples of Luco-Lacinia and Concordia at Agrigento, see Mertens 1984a: 1–53, 65–116. For detailed analysis of the design process of the temple at Segesta, see Mertens 1984a: 45–50. Mertens (1984b: 145) concludes that the approach to design in the fifth century, based on several internal relationships that need not correspond to one another, gave way to a new, simple, and universal commensuration in the fourth century. According to the study of Wilson Jones (2001), this modular approach to design was already at work in the fifth-century examples studied by Mertens.

7 Wilson Jones 2001: 679 and n. 24, with reference to Claude Perrault's theoretical distinction between schematic and customary beauty in the late seventeenth century, as discussed by Herrmann 1973.

8 Typical axial distances between columns are 2.58 m; width of euthynteria is 15.42 m; height of order, or distance from stylobate to top of horizontal cornice is 7.70 m. 2.58 m × 3 = 7.74 m, or 4 cm higher than the actual height. 15.42 m/2 = 7.71 m, or 1 cm higher than the actual height. For measurements, see Koch 1955. See also Dinsmoor 1941; Riemann 1960; Knell 1973; De Zwarte 1996; and De Waele 1998. For additional analysis, see Wilson Jones 2001: 702.

9 Lawrence 1983: 230.

10 Stevens 1940: 4.

11 Such views would have been blocked by both the Sanctuary of Artemis Brauronia and the Khalkotheke, both of which may date to as early as the age of Perikles; see Hurwitt 1999: 215–216, 2005: 13–14 with n. 10.

12 The ratio of the Parthenon's lower column diameter (1.91 m) to height (10.43 m) = 1:5.46; Hephaisteion (1.02 m and 5.71 m) = 1:5.60 m. Parthenon's column height (10.43 m) to entablature height excluding geison (2.7 m) = 1:3.86; Hephaisteion (5.71 m and 1.67 m) = 1:3.43. Measurements from Korres 1994 and Koch 1955. If the elongation of the columns of the Hephaisteion indeed reflects adjustments, it would parallel Mnesikles' addition in the height of the western columns of the Propylaia in order to cope with the effect of distortion created by the steepness of viewing angles on the final approach to the Akropolis; see Büsing 1984. Mnesikles' sensitivity for designing for perception through addition and subtraction anticipates several of Vitruvius' statements (as in *De architectura* 3.5.9, 6.2.2–5, 6.3.11, and several others – see esp. Büsing 1984: 29–32). See Haselberger 1999: 61–62 and n. 233 for additional discussion. See also Haselberger 2005: 109–111 for a lively envisioning of the anxieties and debate that Mnesikles' innovations must have caused for both Pheidias and Iktinos.

13 The term "refinements" was originated by Goodyear 1912; see Haselberger 1999b: 22 with n. 78, 2005: n. 2.

14 This optical function is testified by Vitruvius *De architectura* 3.4.5, 6.2.2; Cicero *Epistulae ad Atticum* 2.4. In a Greek context, this explanation of such refinements as optical corrections is anticipated in the third century by Philon Mechanikos *On Artillery* 50–51. For an excellent discussion of this issue, see Haselberger 1999: 56–60. On the topic of refinements, see Goodyear 1912; Dinsmoor 1950: 164–170; Robertson 1959: 115–118; Martin 1965: 352–356; Coulton 1977: 108–113; Wycherly 1978: 110–111; Haselberger 1999a, 1999b; Höcker 2000; Gruben 2001: 186–188; Beard 2002: 105–107; Hellman 2002: 185–191; Zambas 2002: 127–134; Rocco 2003: 38–39; Haselberger 2005.

15 See Korres 1999: esp. 85–94. The term "refinement of a refinement" was coined by Wycherley 1978: 111, reflecting the intentionality of the rises on the southwest and northwest corners first proposed by Choisy 1865. On doubts concerning the necessary intentionality of this diversion in levels (thereby calling into question the very existence of such "refinements of refinements"), see Zambas 2002: 70 and Haselberger 2005: 145. The basis for such skepticism is the difference in corner levels found also in the Hephaisteion and the Temple of Aphaia at Aigina, equal to ca. 2 cm over 31¼ m and ca. 3 cm over 24 m, respectively. For analysis of the Parthenon's flank curvature that may support these raised levels as intended deviations, see Chapter 3.

16 In the view of Bundgaard (1974: 18-24), the "terrace" is, strictly speaking, an embankment built to retain dirt and debris. For discussion and dating, see Korres 1997: 243; Hurwit 1999: 130, 132–135; 2005: 16–17.

17 The adjustments on the northwest and southwest corners are ca. 3 cm and 5 cm, respectively.

18 For the measurements of curvature on the north stylobate with its maximum rise west of the axis, see Stevens 1943: Figure 1.

19 In the Parthenon, the measured height of the cornice rises only about 0.4 cm above what would otherwise form a theoretical perfect 4:9 rectangle: width of stylobate = 30.880 m; height from top of stylobate to top of geison = 13.728 m. (30.880/9) × 4 = 13.724 m, a difference of only 0.4 cm. Measurements from Dinsmoor 1950. In the Hephaisteion, the relationships are 1 cm and 4 cm short of theoretically perfect 1:2 and 1:3 relationships, respectively.

20 On the term *anagrapheus*, see Coulton 1976a. On *paradeigmata*, see Jeppesen 1958; Pollitt 1974: 204–215; Coulton 1975: 94, 1977: 54–58; and Hellman 1992. Tantalizing

testimony for *paradeigmata* is found in a painted inscription from an Archaic period monument of the sixth century: the water tunnel of Eupolinos, which features a more-than-five-meter-long section of tunnel with a painted inscription below eye level reading "ΠΑΡΑΔΕΓΜΑ." There are, however, complexities associated with the date of the inscription and how, exactly, the particular section of tunnel should function as a *paradeigma*; see Kienast 2004, with the letter-by-letter photographic illustration in plate 14, and earlier references cited. An interesting study suggests how the process of the *anagrapheus*, as a model for architectural elements, may be reversed. Taking the volute of the Ionic capital of the Temple of the Athena Polias as the model, a modern machine can be assembled to duplicate its forms as a drawn template; Stevens 1956. Similar precepts to those proposed by Stevens may be applied to vector-based computer-aided drawing software.

21 These *syngraphai* are known from inscriptions, and make no reference to drawings; see Coulton 1977: 54–55. Anyone who wonders how a text could provide the specificity and clarity required to create a building should consult the *syngraphai* of the 340s for the Arsenal of Piraeus by the architect Philon of Eleusis (*IG*^{2} 1668). Inscribed on a block of Hymettian marble, these *syngraphai* provide precise directions for excavating and leveling of the site; the laying of the different parts of the building's foundations and leveling course; the technique for the masonry of the walls; and the exact number, size, and placement of every architectural feature (columns, orthostates, doorway jambs and lintels, the cornice, windows, cross-beams, and ridge-beam, etc.). For an English translation with text and commentary, see Ludlow 1882, with additional commentary in Marstrand 1922. See also the helpful reconstructed drawings in Davis 1930. I thank James Dengate for these references.

22 Coulton 1974: 86, 1975: 90–94, 1977: 53, 55–56.

23 Senseney 2007: 577.

24 The exceptions are, however, of great consequence. In particular, see the discussion of single-axis protraction in fifth-century temples in Chapter 3.

25 Coulton 1974.

26 See MacDonald 1986: 250, articulating the difference between Greek and Roman architecture in terms of the former's emphasis on "sculptural and tectonic" qualities of individual elements as opposed the latter's emphasis on an overall visual effect. I would suggest this emphasis of the whole at the expense of the individual as an outcome of a design process focused on reduced-scale architectural drawing.

27 The same may be said of south Italian examples like the "Temple of Hera II" at Paestum, produced in a milieu where numerical relationships clearly governed the relationships of architectural elements in both elevation and plan. Even Henri Labrouste's superb illustrations of this temple executed in the Beaux-Arts tradition in the 1820s cannot properly convey the effects of its forms in three dimensions. For these drawings (published posthumously), see Labrouste 1877.

28 Hahn 2001: 113. For the discovery of the chalk drawings, see Kienast 1985.

29 Of course, even if this technique of 1:1 chalk drawings was employed extensively in Greek architecture, its traces have largely vanished.

30 See Hahn 2001: 112–113, based on Schneider 1996: 27–48 with Figures 14–16, 30–31. Hahn implies that Peter Schneider, the excavator of the two buildings at Didyma, concluded that ichnography had been at work in these Archaic buildings. Schneider makes no such statement, however.

31 For example, see Morris 1992: Figure 8a, where an Etruscan gold bulla of 475–450 BC shows Daidalos as a carpenter with his T-square.

32 For revised dating of Hermogenes, see Kreeb 1990.

33 In the seventh century, Ionians fought as mercenaries under the Saite ruler Psamtik in his quest to regain hegemony over Egypt, followed by the establishment of Naukratis as permanent trading post for Milesians in Egypt (Herodotos 2.151–152). Evidence for scale architectural drawings is well documented in the ancient Near Eastern world. For a highly inclusive recent study exploring the complexities associated with interpreting Egyptian techniques of architectural planning, including surviving working drawings, see Rossi 2004. Testifying to the employment of reduced-scale ground plans in Mesopotamia is a little-known incised tablet of baked clay in Berlin, depicting a house in plan along with cuneiform inscriptions indicating the dimensions of rooms and the thickness of walls (Staatliche Museen zu Berlin, Vorderasiatisches Museum, VAT 413). Also from Mesopotamia, the seated statue of ca. 2150 BC in the Louvre featuring an incised drawing of an architectural plan on the lap of Gudea, the Neo-Sumerian ruler of Lagash, is well known; see Parrot, *Tello* 1948: 161, 163, Plate 14. The image is an appropriate one for a leader who is known to have rebuilt some fifteen temples in Lagash, and surviving inscriptions narrate Gudea's dream in which the city's patron god Ningirsu appeared to him to express his desire that a temple be built; see Roux 1964: 165–167. If the folded hands in this and similar statues convey a gesture of piety, the work may show Gudea presenting the temple to the god, and would thereby locate the function of the architectural drawing in a votive context. For the gesture of the folded hands as a pan-Mesopotamian expression of respect, see Cifarelli 1998. What we cannot know, however, is whether the image may instead represent Gudea offering the plan to the god for his approval, which would thereby place the drawing in a planning context. In any case, Gudea's design represents a complex assemblage of rooms and therefore pertains to a building type that a drawn plan would serve, as opposed to the simple, prismatic temples and stoas of the Archaic and Classical period Greeks. For architectural drawings of the ancient Mediterranean world in general, including Near Eastern, Greek, and Roman material, see Heisel 1993.

34 Vitruvius 1.2.2. discusses ichnographies, elevations, and perspective drawings.

35 However, the absence of axial or orthogonal arrangements in groups of such buildings (as in the Propylaia, Parthenon, and Erechtheion on the Athenian Akropolis) should not in itself be taken to indicate an absence of ichnography. Rather, the studied avoidance of these principles could conceivably characterize the gradual, decade-by-decade design process of ancient environments at a reduced-scale, planar level. In Chapter 4, I discuss how ichnography may have certainly *encouraged* principles of axial symmetry and orthogonal arrangement in some environments, but this suggestion in no way implies that this result is necessary, that such principles are contingent on ichnography, or that the absence of these principles precludes ichnography at a given location during a given period of building activity.

36 An excellent summary of the mixtures of architectural traditions, innovations of typology and proportions, and intentional irregularities in the sizes of elements is Korres 1994: 78–91, who aptly characterizes the Parthenon as "the most undogmatic achievement of Classical architecture" (79). Although my discussion here of the possible role of ichnography in the Parthenon focuses on the stylobate, it is important to note the recent argument of Waddell 2002 for the importance of the krepis in addition to the stylobate in the Parthenon's design. Whereas Waddell does not believe that drawings were a necessary part of design process for the Parthenon (n. 34), his proposal carries an interesting suggestion for how its ground plan may have determined the building's overall spatial arrangement. Based on the

observation that triglyphs commonly align with the joints of the krepis blocks, this argument advocates the importance of the krepis in determining the size of the triglyphs in Doric temples of the fifth century. The suggestion of this formal correspondence may be that the temple's overall proportions and all of its individual relationships had to be worked out in their entirety before construction began, as opposed to the notion that Greek design process evolved throughout the various stages of building. This explanation is consistent with an analysis finding that the vast majority of temples show what has been framed as a meaningful relationship between the ratio of the numbers columns and the ratio of overall proportions on the short sides and long flanks of the krepis or stylobate. In the specific case of the Parthenon, the 8 × 17 columns result in a ratio of 1:2.13. This ratio is argued to deliberately relate to the 1:2.15 ratio of the overall dimensions of the krepis (33.68 m by 72.31 m). Yet the difference between 1:2.13 and 2.15 is over 0.9%. In terms of actual measurements, this tolerance would correspond to 26 cm or 56 cm (!) on the short ends or flanks of the krepis, respectively. This argument for the importance of the krepis in the design of the Parthenon is not directly incompatible with other observable ratios, but the untidiness of its related numbers should separate it from the more cleanly supported proportional relationships found on the stylobate. As such, we may confidently set aside the proposed importance of the Parthenon's krepis, turning our attention instead to stylobate and the features it supports.

37 See Korres 1994: 89. For arguments favoring the existence of a hypothetical phase of construction between the Archaic and Periklean Parthenon, see Carpenter 1970: 44–45, 66–67; Bundgaard 1976: 48–53, 61–70. For a recent summary and bibliographic sources on the relationship between the Archaic and Periklean Parthenon, see Barletta 2005: 68–72.

38 On the innovation of the pi-shaped colonnade, see Gruben 1966: 180–182; Gruben 2001: 199–202.

39 For the 4:9 ratio of column diameter to axial distances: Stuart and Revett 1787: 8; Penrose 1851: 8, 10, 78; W.W. Lloyd in Penrose 1888: 111–116. For that of dimensions of the stylobate (30.88 × 69.5 m): Dinsmoor 1961; Gruben, 1966: 167; Gruben 2001: 173–190; Barletta 2005: 72–88.

40 On drawing surfaces available to ancient architects, see Coulton 1976: 52–53.

41 See especially the drawing for working out entasis (ca. 1.23 × 1.82 m including base), as well as the related diagram of the entire height of the column depicted horizontally, measuring ca. 18 m long; Haselberger 1980: 191–203 and Figure 1. For additional large-scale drawings at the Didymaion, see the working drawings for the pediment and cornice of the Naiskos, incised into the west socle wall of the adyton; Haselberger 1983: 98–104 and Plate 13.

42 For discussion and sources, see Korres 1994: 84–86.

43 For the complexities of designing for an octastyle façade of the Doric order, see Winter 1980: 405–410.

44 Korres 1994: 88–90.

45 As opposed to recent proposal of Waddell 2002: 14–15 for the significance of the ratio of 1:2.13, the recognition of the stylobate's ratio of 4:9 dates back to the eighteenth century, first noted Stuart and Revett 1787: 8.

46 On corner contraction, see Coulton 1977: 60–64; Gruben 2001: 42–43. On the exaggerated contraction in the Parthenon, see Gruben 2001: 179–180; Haselberger 2005: 124–125.

47 Korres 1994: 90.

48 See Pollitt 1974: 17–21; Pollitt 1995.

49 Compare Janaway's observation of the longstanding notion of "the view of art as the supreme route to a knowledge Plato thought reserved for philosophy – art as uncoverer of eternal Ideas, or some 'higher' reality" (1995: 186).

50 Codices: *ideae* (1.2.1-2).

51 Haselberger 1997: 77, 92–94; Senseney 2007: 560; Senseney 2009: 44–45; Senseney and Finn 2010: 88. See Introduction in this book.

52 Nonetheless, there exists a compelling interpretation of Plato in Kantian terms from the early twentieth century. See particularly Natorp 1903 and Stewart 1909.

53 This passage begins Plato's introduction to his well-known discussion of the manufacture of couches (596e–597e), which clearly lays out his arguments for the relationship between intelligible Ideas and sensory imitations. The statement that no craftsman makes the Idea does not exclude a different kind of craftsman altogether: The divine craftsman or Demiurge of the *Timaeus* discussed below.

54 For ancient usage, Liddel et al. 1940: s.v.

55 Conflation of the common and specifically Platonic usage of the term can lead to unnecessary confusion, as in Janaway (1995: 112), asking, "Should we not be surprised that a humble craftsman is now granted a glimpse of the Form as the guiding principle in the production of beds, when earlier in the *Republic* much was made of the fact that only philosophers have access to the Forms?" Janaway classifies Plato's statement as an anomaly.

56 The following analysis is that of Nabers and Ford Wiltshire 1980, expanding upon Kayser 1958: 49–60; Holloway 1966: 60–64; Holloway 1973: 64–68.

57 Oddly enough for a temple of the Doric order, the interaxials of the peripteron are uniform throughout and equal to eight Doric feet. In elevation, accordingly, the long sides of the peripteron measured axially equal 96 feet, whereas the height from the stylobate to the top of the horizontal cornice measures 28 feet. The diagonal measures 100 feet, resulting in a Pythagorean triangle in which the hypotenuse shares a whole number relationship with the sides. In plan, furthermore, the short and long sides of the peripteron measured axially equal 40 and 96 feet, respectively. The diagonal measures 104 feet, resulting in a 5:12:13 triangle. Since the hypotenuse shares an integral ratio with the short and long sides, the result is again a Pythagorean triangle.

58 Vitruvius 3.1.5.

59 Porphyry *Vita Plotini* 20; Iamblichus *Vita Pythagoreae* 150; Lucian *Vitarum auctio* 4; Sextus Empiricus *Adversus Mathematicos* 7.95. See Pollitt 1974: 18, 421; Stewart 1978: 128–130; Nabers and Ford Wiltshire 1980: 280; McEwen 2003: 45–46.

60 See Senseney 2007: 572–593. For additional analysis including Temple A's modular basis, see Chapter 4 of this book.

61 More specifically, the graphic underpinning controls the outer corners of the naos and the relationship of the antae of the pronaos to the temple's outer back corners (at the euthynteria).

62 For analysis of these terms and their implications for Vitruvius' understanding of ichnography, see Chapter 4 of this book.

63 Lauter (1986: 30–31) suggests precisely this: Vitruvius' discussion of *taxis* and *diathesis* takes inspiration from architectural theory dating from fourth century.

64 Coulton 1977: 15–29.

65 For an excellent and concise introductory discussion of the role of Pythagorean thought in the development of notions of order in the Archaic and Classical periods and its influence on art, see Stewart 2008: 45–51.

66 Regarding number and truth, see also *Republic* 525b.

67 See the passage on the "Divided Line" (*Republic* 510a-d) in which Sokrates discusses the place of geometric images in the pursuit of real knowledge grasped by the mind rather than the eyes.

68 On this passage, see also Pollitt 1974: 16–17 with discussion of Plato's comments about beauty and the arts in Plato *Statesman* 284a-b.

69 Maguire 1965: 175–176. See also Janaway 1995: 69.

70 For Plato's concept of beauty or fineness, see Brumbaugh 1976; Alexandrakis and Knoblock 1978; Janaway 1995: 58–79.

71 On the difficulty in determining whether παράδειγμα here refers to a physical (reduced-scale?) model or a canon of ideal proportions, see Pollitt 1974: 213–214.

72 On the interchangeability of beauty and truth in Plato, see Maguire 1965: 180–182.

73 Maguire 1964.

74 Maguire 1964; Maguire 1965: 171–172 with n. 3.

75 Maguire 1965: 178–179.

76 For a catalog of citations of seeing and Ideas, see Mohr 2005: 248–249. For discussion, see also Nehamas and Woodruff 1995: xlii–xliii.

77 Also, "the eye of the soul" (τὸ τῆς ψυχῆς ὄμμα, *Republic* 533d).

78 For expanded analysis of the eyes and their relationship to the sun and the Idea of the Good, see Nightingale 2004: 10–11, 112–113.

79 On the importance of the sense of sight for Plato, see also Keuls 1978: 33–35.

80 Nightingale 2004: 88.

81 Nightingale 2004: 159.

82 In the *Symposium*, the philosopher's seeing of the Idea of Beauty results in his giving birth to virtue (210e–212e); see Nightingale 2004: 84. For the seeing of Ideas, see also *Philebus* 61e1.

83 On the relationship between Greek art and ἀλήθεια, see Irlenborn and Seubold 2006: 293–294. On the problematic relationship between ἀλήθεια and concepts of truth and Heideggerian "Un-Verborgenheit," see Helting 2006. One difficulty with bringing in this discussion to an interpretation of Plato is the prominent Aristotelian character in the thought that Heidegger describes. On the other hand, scholars commonly employ Aristotle in coming to terms with Plato; for explicitly Aristotelian interpretations of Plato, see Johansen 2004: 5; Fine 2003: 41. For criticism, see Mohr 2005: xiv–xv. My own views developed below are not sympathetic to such interpretations. Rather, I find Plato and his cosmology useful as a possible reflection of craftsmanship in the Classical period, however altered to suit his own needs.

84 Heidegger 1971: 159. For τίκτω as giving birth, see McEwen 1993: 55 and 146 n. 6.

85 This and all subsequent references to Philon's treatise cite the edition of Marsden 1971.

86 See analysis and cited sources in the Excursus to this book.

87 See Stewart 1990: 20, 92; Haselberger 1999: 61 with n. 227.

88 Mohr 2005: ix. God as ποιητής: *Timaeus*. 28a; *Philebus* 27a. God as δημιουργός: 28a, 29a, 41a, 42e, 68e, 69c; *Philebus* 27b.

89 Benjamin 1968.

90 See Derrida 1985.

91 Plato's full argument begins at *Philebus* 55e. For discussion, see Mohr 2005: 17. More specifically, building is "scientific" in the sense that is "more of a *techne*," meaning that for Plato, its practices are grounded in a kind of knowledge that is measurable and grounded in numbers rather than intuitive or empirical. For consideration of what this reason for Plato's elevation of building may impart to his reduced status

of poetry as an expression based on inspiration rather than precise measurement, see Janaway 1995: 16, 35, 174. In essence, for Plato, a true *techne* is grounded in measurable knowledge, and not just pleasure; Janaway 1995: 36–57.

92 Material pertaining to architectural drawing introduced in Chapter 3 has an important bearing on this issue.

93 For Plato's account of numbers in the *Republic* and *Philebus*, see Mohr 2005: 229–238.

94 For full analysis, see the Excursus to this book.

95 Soubrian 1969: ix–xi suggests that Vitruvius may have been the earliest writer to consider timepieces under the heading of architecture, but this idea can hardly be asserted in the absence of any surviving commentaries on building named by Vitruvius at 7.praef.12-17. McEwen 2003: 229–250 accounts for the appearance of a discourse on timepieces in Vitruvius' work through reference to specifically Roman cultural concerns. Although this explanation is convincing inasmuch as it articulates how *gnomice* resonates in a Roman context, for reasons I explore in the following chapter, I see timepieces as related to architecture through probable connections between astronomy and building in a Greek cultural context.

Chapter Two. Vision and Spatial Representation

1 Copernicus, *De Revolutionibus* 1.6.

2 For the dioptra and its operations, see Lewis 2001: 51–108.

3 For assumptions required to explain Euclid's argument and additional commentary, see Berggren and Thomas 1996: 54–55.

4 Berggren and Thomas 1996: 28–29.

5 For a general introduction to ancient Greek optical theory, shadow painting, and stage painting (including linear perspective), see Summers 2007: 16–39.

6 See Brownson 1981: 168.

7 White 1987: 249–258.

8 In Alberti's attempt to distinguish between drawing for painting and architecture in the fifteenth century, he stresses between the painter's use of shadow for the appearance of depth and the architect's use of precise measurements of dimensions (*On Building* 2.1); see Rykwert et al. 1988: 34.

9 As pointed out by Ackerman (2002: 64 n. 27), it is not readily clear why Vitruvius should have characterized linear perspective in terms of lines receding toward the center of a circle specifically, suggesting the arbitrary or artificial nature of the construction. For possible confusion in our understanding of Alberti's *pyramis* as a necessarily rectilinear-based pyramid as opposed to his likely intention to continue the traditional notion of a cone of vision, see Gadol 1969: 29–31; Lindberg 1976: 263–264 n. 8.

10 Earlier studies emphasizing a discordance between the *Optics* and linear perspective include Hauck 1897; Panofsky 1975. These arguments are superseded by the close readings of Euclid's proofs by Brownson 1981.

11 For the distinction between Vitruvius' description of *skenographia* as comparable to that found in Campanian frescoes and the significantly different Renaissance understanding of the passage, see Thoenes 1993: 566.

12 Beare 1906: 46–47.

13 See Lindberg 1976: 3–4.

14 Lindberg 1976: 13.

15 Berggren and Thomas 1996: 28–29.

16 For dating, see Mogenet 1950: 5–9.

17 For related analysis, see Evans 1998: 87–88.

18 *Timaeus* 47a-b. On the kinship of human reason and the revolutions of the cosmos, *Timaeus* 90c-d; Plato *Laws* 966e–967c. See the arguments of Nightingale 2004: 74–79. For the relationship of Plato's World Soul and Parmenides, see Dicks 1970: 118.

19 On the discovery of the circular motion of planets, Plato *Laws* 821e–822a. The insistence of Cornford (1937: 73–74) that Plato based his conception of the cosmos on three dimensional objects like an armillary sphere, astrolabe, and orrery is anachronistic; see Dicks 1970: 120–121.

20 See Dicks 1970: 108, 123, 152–153; Nightingale 2004.

21 Eudoxos' *Phenomena* is preserved in verse in the work of the same title by the didactic poet Aratos in the following century. Other works included his *On the Heavens* and *Mirrors*; see Evans 1998: 75–76. For a detailed historical study with analysis of sources, see Dicks 1970: 151–189.

22 Dicks 1970: 156–157. For Eudoxos, each division would have simply been one-twelfth of a circle. The figure of 30° of course depends on the notion of a 360° circle, which Eudoxos did not use. For the possibility that Plato's emphasis on the twelve deities in the heavens (*Phaedrus* 247a) may reflect the image of the zodiac, see Dicks 1970: 114–115.

23 Dicks 1970: 156; Evans 1998: 75–76.

24 Dicks 1970: 176 (emphasis Dicks). In the prior view concerning the retarding effect of philosophically-based circular orbits, Dicks (n. 321) cites Africa 1968: 37: "Hamstrung by the dogma that celestial motion was perfect and circular, Greek astronomers expended great ingenuity to reconcile the erratic behavior of the planets with their presumed circular motion."

25 Dicks himself (1970: 169, 176) emphasizes this differing approach of the Babylonians, as well the Greek and non-Babylonian origin of the geometric conception of the universe and the unlikelihood that the zodiac represents Babylonian influence.

26 On the notion of visuality, see Jay 1988: 16–17; Bryson 1988: 91–92.

27 De Jong 1989. For an assessment of de Jong's (1989) geometric analysis of Hermogenes' Temple of Dionysos at Teos (or more specifically, its Roman restoration), see Senseney 2009: 40–42.

28 On a related point, a recent attempt to see a geometrical ratio at work in an Etruscan complex of the Archaic period is inherently flawed. During my most recent visit in July 2007, it was still on display in a graphic illustration in the Museo Archeologico Nazionale at the Palazzo Vitelleschi in Tarquinia. The monument in question is the "complesso sacrco-istituzionale" containing the so-called beta building begun in the seventh century B.C. The proposal finds a multiplication of $\sqrt{3}$ for the shorter dimensions of walls to correspond to the orthogonal-related longer dimensions in the length and width of the beta building itself, the alae and lateral walls of its surrounding enclosure, and the area between before its façade; see the entries in the catalogs of two recent exhibitions: Invernizzi (2000), with illustrations on 268; Invernizzi (2001), with Figures 30–34 on 35. The chief problems with this proposal are the selection of arbitrary points along incomplete foundation walls, and the poor correspondence between actual and theoretical dimensions. In particular, the proposed area before the beta building does not correspond to any clear architectural feature for the measurement of its shorter dimension. For the lateral areas, the width of ca. 9.20 m renders a length of 15.935 m when multiplied by $\sqrt{3}$, a difference of more than 20 cm or 1.5% from the actual length of ca. 15.70 m! We are therefore left with the dimensions of the beta building itself whose long dimension of ca. 11.70 m is still off by more than 0.8% from the expected 11.605 m as the product of $\sqrt{3}$

and the width of ca. 6.70 m. This tolerance would perhaps be acceptable, were this kind of geometry convincing in an Archaic Etruscan complex in the first place.

29 For studies of the Tholos, see Charbonneaux 1925; Bousquet 1941: 121–127; Bousquet 1961: 287–298; Ito 2005: 63–133. The recent analysis of its ground plan as based on three circumscribed pentagons is interesting if not altogether convincing; see Hoepfner 2000.

30 Horiuchi 2004: 136.

31 Horiuchi 2004.

32 Stylobate diameter (13.63 m/5) × 3 = 8.178 m, a difference of 1.8 cm from the actual 18.16 m diameter of cella including walls. Properly speaking, however, the Vitruvian passage does not express the relationship in such mathematical terms as a ratio of 3:5 diameters or the use of the compass, but rather simply the setting of the cella wall back from the edge at a distance of "about" a fifth of the breadth of the stylobate: *Cellae paries conlocetur cum recessu eius a stylobata circa partem latitudinis quintam*. Geertman (1989) argues that *circa* may indicate Vitruvius' reference not to 3/5 (or 0.6) precisely, but rather the irrational ratio $(2-\sqrt{2})/1$ (or .586). Wilson Jones (2000a: 104) alternatively suggests that it may reflect Vitruvius' understanding that the exact thickness of the wall need be decided according to the nature of the particular project. However, this interpretation simply privileges the internal rather than external diameter of the cella; even though the wall thickness is variable, its placement with respect to the edge of the stylobate remains unchanged, and it is unhelpful to disregard the stylobate's edge as Vitruvius' primary consideration when he expressly states that it was. I would suggest that both interpretations read too much into "about," and that Vitruvius simply passes on a general rule that is consistent with Late Republican tholoi like the one by the Tiber discussed below, as well as Temple B in the "Area Sacra" at the Largo Argentina, whose original cella of ca. 9.3 m shared a 3:5 relationship with the stylobate of ca. 15.5 m. For Temple B, see references in the reports by Marchetti-Longhi (1932, 1936, 1956–58). For the excavations in the Area Sacra, see Marchetti-Longhi 1970–71.

33 For the Tholos at Epidauros, see Roux 1961; Burford 1969: 63–68, 114–116.

34 The main archaeological publication on the tholos is Rakob and Heilmeyer 1973. For the building's almost certain identification as the temple of Hercules Olivarius, see Coarelli 1988: 92–103, 180–204. For an alternative identification with Mummius' temple of Hercules Victor, see Ziolkowski 1988. Yet as Coarelli emphasizes, an inscription discovered near the tholos appears to have read, [HERCVLES VICTOR COGNOMINATVS VVLG]O OLIVARIVS OPVS SCOPAE MINORIS, probably pertaining to the temple's cult statue. The date of the tholos is suggested by multiple parallels with the remains of the temple of Mars *in Circo*, commissioned by D. Iunius Brutus Callaicus after his triumph over the Callaeci in Spain in the 130s, and identified with the remains beneath the church of S. Salvatore in Campo. The plan of this temple is now recognizable through its identification with the peripteral temple with an *adyton*, visible in panel 37, fragment 238 of the Severan Marble Plan; see Rodriguez-Almeida 1991–1992: 3–26. The parallels with the tholos include construction in Pentelic marble; the cutting of the lower column drums from the same block as the base, consisting of a single torus rather than the full Attic base common in Rome in the early first century; the presence of surrounding stepped krepidoma rather than an axial flight of stairs connected to a tall podium, resulting in these two temples as the only known examples of the Greek feature in Republican Rome; and finally the employment of the same Greek sculptor, Skopas the Younger, for the cult statues of both temples; see Gros 1973: 151–153.

35 For attributions to the Greek architect Hermodoros, see Gros 1973: 158–160. Gros furthermore interprets the combination of similarities and discrepancies between this tholos and Vitruvius' recommendations for round temples as evidence for a lost text written about the tholos that Vitruvius consulted, as opposed to the actual construction by an Italian atelier that diverged from the architect's conception.

36 Diameters of the cella including the wall thickness and the total stylobate average ca. 9.9075 m and 16.517 m, respectively. These numbers produce a 3:5 ratio with a difference of only 0.1%. For these measurements and others, see Rakob and Heilmeyer 1973: Figure 1.

37 This nongeometric understanding of the round temple is consistent with Wilson Jones's convincing arguments countering Geertman's geometrical interpretation of the Late Republican tholos at Tivoli; Wilson Jones 2000a: 103–106.

38 For *syngraphai*, see Coulton 1977: 54–55 and Chapter 1 in this book.

39 For this argument concerning traditional temples, see Mertens 1984b: 137, 144–145 and Chapter 1 of this book.

40 Regarding theaters and other aspects relating to Book 5 of Vitruvius' *De architectura*, I regret that I was unable to access a copy of Saliou 2009 before going to press.

41 For a discussion of questionable attempts to see Vitruvius' prescriptive passage on the Latin theater in later Roman theaters, see Sear 1990 and 2007: 27–29.

42 Following Gros (1994: 59–64) and McEwen (2003: 326 n. 167), I quote this phrase from the Harleian manuscript 2767 in the Loeb edition of Granger 1931.

43 Fensterbusch 1964: 99–100. Favoring the significance of the astrological reference is Gros 1994: 64–65, with passage restored at 59 with n. 14 and Gros's comparison between the construction of Vitruvius' Latin theater with the contemporary astronomical diagrams of Geminos of Rhodes at 65–66. As argued in the present and following chapters, the connection with astronomical diagrams concerns material long predating Vitruvius' *floruit*.

44 On Vitruvius and the education of architects, see Rowland 1999: 7–8.

45 For the drawings in general, see Haselberger 1980, 1983, and 1985. For Haselberger's restoration of one of the rosettes, see 1991: esp. 99–101 with Figure 2.

46 The earliest surviving example that I have encountered is late Archaic, drawn on one of the fragments of poros discovered with the small models of triglyphs and other features deposited into the construction layers of the Temple of Aphaia at Aigina (ca. 500 B.C.), and on display at the site's museum (Aigina Inv. No. 78/157). We cannot expect such informal graphic exercises or steps of the design process to survive, however, and the rare examples cannot begin to suggest the antiquity and frequency of the form. For the poros models at Aigina, see Bankel 1993: 111 with Plate 35.

47 See Bartman 1993: 64, with additional examples on the reused lintel of the Badminton sarcophagus.

48 Like other compass-based constructions, the form of the six-petal rosette was also eventually adopted for the geometric motifs of Roman floor mosaics, as in the *cubiculum* of the House of the Surgeon in Rimini; see Gourevtich 2008: 49, Figure 1.

49 Vitruvius describes the harmonic principles at 5.4.1–9 and references the diagram of Aristoxenos and its specifications at 5.6.2–6.

50 The construction of Pompey's complex as early as the 50s is a certainty, probably begun at the time of Pompey's triple triumph in 61; Sauron 1987. The exact dedication date of the complex is disputed, however. According to Pliny (*Natural History* 8.20), the complex's *templum Veneris Victricis* was dedicated during Pompey's second consulship (55 B.C.), whereas Aulus Gelleius (*Noctes Atticae* 10.1.6–7)

connects the dedication of the shrine (*aedes Victoriae*) with Pompey's second consulship (52 B.C.). Hanson (1959: 43) favors the testimony of Pliny and assigns the dedication of the Pompeianum to 55, followed by Richardson 1992: 383–384 and P. Gros in *LTUR* 5, 35–38. Donald Strong (1968: 101), however, suggests a dedication date of 55 for the theater, and 52 for the Temple of Venus Victrix. According to Boëthius (1978: 205), the complex was "built during Pompey's second consulship in 55 B.C. and dedicated in 52," and the same dating reflects in Sear (2007: 58). Coarelli (1997: 567–569) convincingly argues that Gelleius' testimony for the dedication of an *aedes Victoriae* corresponds to the temple designated solely by the initial *V* in the calendars, a temple listed as in the Pompeianum in addition to that of Venus Victrix, as well as Honos, Virtus, and Felicitas – all presumably located at the top of the cavea (Suetonius *Divine Claudius* 21.1); see following note. Therefore, the temple from Gelleius represents the fifth temple, dedicated to Victoria in 52 and not synonymous with the Temple of Venus Victrix dedicated in 55.

51 Tertulian (*De spectaculis* 10.5) cites Pompey's intention that the combination of *Veneris aedes* and *theatrum* was to be *Veneris templum* with *gradus spectaculorum*, and that the monument was to be dedicated as a *templum* rather than a theater. According to Aulus Gelleius (*Noctes Atticae* 10.1.6–7), Tiro had similarly characterized the theater as a stairway for the temple. In describing the elaborate dedication ceremonies for the complex, Pliny (*Natural History* 8.7) never even mentions the theater, but simply the dedication of *templum Veneris Victricis*. In addition to the Temple of Venus Victrix, the Pompeianum included shrines to Victoria, Honos, Virtus, and Felicitas. Because the literary sources focus on the Venus temple as the *raison d'être* for the complex, these other shrines were doubtlessly less prominent. Their exact location within the complex is uncertain, but Suetonius (*Divine Claudius* 21.1) refers to *superiores aedes* in his account of the rededication ceremonies under Claudius. Like the Venus temple, then, some of these would have likely appeared atop the *cavea*, and were likely set radially with respect to the orchestra.

52 For the monument's history and recent excavations, see Packer 2006 and 2007; Sear 2007: 57–61.

53 On the location of the *curia* within the Pompeianum: Suetonius *Divine Julius* 88, *Divine Augustus* 31; Dio Cassius 44.16; Plutarch *Brutus* 14; Nikolaos of Demascus *Life of Augusts* 83.

54 For the fragments on the Severan Marble Plan, see Rodriguez Almeida 1981: Plate 37. From Propertius (2.32.11–16) we know that the porticoed enclosure was a planted space, incorporating plane trees cut to a uniform height, fountains, and statues; see Gleason 1990. On the Marble Plan fragments, the central space of the Porticus Pompeianae is depicted with two long rectangles – perhaps pools – each corresponding to an actual size of ca. 23 by 100 m with an intervening passageway ca. 12 m wide on the central axis with the Curia Pompei. The rectangles are defined by rows of small squares with a dot in each center. Excavations have uncovered the concrete foundations of one of these elements, which lacks the necessary strength of a monumental column foundation; Gianfrotta, Polia, and Mazzacato 1968–1969. Coarelli (1997: 573) therefore identifies these elements as the sculptures or fountains from Propertius' testimony.

55 According to Plutarch (*Pompey* 42.4), Pompey's theater was modeled specifically on the theater at Mytilene on Lesbos, a building that we know little about beyond the approximate diameter of its orchestra (25 m) at its hillside location; Sear 2007: 57.

56 Roux (1961: 184-186) and von Gerkan (1961: 78–80) reject Pausanias' (or his sources') attribution of the tholos and theater, respectively. For a more accommodating view

of at least the plausibility of the same architect for both projects, see Winter 2006: 104. We might also consider that there is no reason to discount that the design of the theater may have preceded its construction by several decades. Whatever the case, Käppel (1989) views the geometry of the theater's design to indicate the work of a single architect. The *Canon* of the famous Polykleitos of the fifth century is addressed in Chapter 1 and its supporting Excursus.

57 Akurgal 1973: 74. The relationship between the structures and the theater is perhaps best appreciated with the help of the restored model of Pergamon's akropolis in the Pergamon Museum (Staatliche Museen, Berlin). For the theater, see Radt, 1999: 257–262.

58 The Greek theater's radial divisions are therefore constructed by the relationship $1/\sqrt{2}$ based on the square, as opposed to the relationship $\sqrt{3}$ of the triangular underpinning of the Latin theater; See Gros 1994: 332, with comparison to Euclid *Elements* 13, proposition 12 at n. 19.

59 An excellent study of Vitruvius' Greek theater is Isler 1989, whose results I summarize here.

60 Love 1970: 152.

61 Von Gerkan 1921: 116–118 with Plate XXIX.2.

62 Isler 1989: 143–150.

63 Isler 1989: 149.

64 Isler 1989: 141.

65 Ferri 1960: 192–194. See also Trojani 1974–1975; Gros 1994: 63.

66 Goette 1995: 9–48. For a review of the literature on the *koilon*, *skene*, stagehouse, and stoa, and Temple of Dionysos, see Winter 2006: 99–100.

67 The theory that the earliest version of the Theater of Dionysos may have been rectilinear originates with Anti 1947. See also Anti and Polacco 1969: 130–159; Camp 2001: 145–146; Winter 2006: 97. This unprovable though likely proposal has not been accepted by Webster 1956: 6; Bieber 1956: 55. If correct, Anti's theory may suggest that the circular, radial form is not an obvious choice for theaters, but rather one that was created at a specific time and place for a particular reason, after which the influence spread. As seen at the Minoan palace at Phaistos, for example, places for spectators to view ritualistic spectacle were straight stairways as early as the period of the Old Palace (1900–1700).

68 For the difficulties in separating Greek ritual and drama, see Csapo and Miller 2007.

69 See Thompson and Wycherly 1972: 127.

70 For this terminology at Sparta, see McEwen 1993: 58.

71 Liddel et al. 1940: s.v.

72 See Winter 1965: 104–105.

73 As argued by Nightingale 2004: 50–52 and n. 38, this general sense of *theorein* as seeing or observing is found in Herodotos 3.32, 4.46 and Thucydides 4.93.1, and is never used in reference to a *theates*.

74 For the character of performances of the City Dionysia (Dithyrambs, Assemblies, and processions of orators and *chorêgoi*) as "political ritual" rather than just the art of the art of drama, see Goldhill 2000: 162. For the preoccupation of the act of looking on in the language of tragedy in particular (with telling quotes at Sophokles *Trachiniae* 1079–1080 and Sophokles *Oedipus the King* 1303–1305), see Goldhill 2000: 174 and Zeitlin 1994.

75 See Nightingale 2004: 3–7, 40–71.

76 Nightingale 2004: 72–138. Nightingale's argument is anticipated by Goldhill 2000: 169–172.

77 I take this term for Plato's long-noted close relationship with the art of drama from Cain 2007.

78 See Winter 1965: 105.

79 Dunbar 1995: 1.

80 For speculation on its reception, see Dunbar 1995: 14.

81 For a consideration of this passage in the context of Vitruvius and classical urban planning in relation to the geometry of the winds, see Haselberger 1999c: 96.

82 For other examples, see Dunbar 1995: 552.

83 For ἰδέα as kind or sort, Liddel et al. 1940: s.v.

84 This translation deserves explanation. On the authority of the manuscripts, Wycherly 1937: 22, 23, 24 returns to κατ' ἀγυιάς, citing metrical grounds in the shortening of the penultimate of ἀγυιάς preceding the final vowel as per White 1912: § 801. The advantage is avoidance of the agricultural connotation of γύης in the sense of a plot, favoring "streets" in a manner more consistent with Meton's purpose. In response, Dunbar (1995: 553–554) favors κατ' ἀγυιάς as a corruption rather than original. I agree with Dunbar's observation that even a city must begin as articulated plots of land rather than streets, thus obviating the need to uphold κατ' ἀγυιάς. In other words, γύης need not carry a strictly agricultural connotation, and in the context of planning a city may be understood in a general sense as designated areas or sections.

85 See Wycherly 1937: 24–25 with Figure 1.

86 See Dunbar 1995: 555, with sources cited.

87 See Wycherly 1937: 25–27.

88 Wycherly 1937: 26 successfully argues against the need to view Meton's lines as reflecting the geometrical problem of "squaring the circle."

89 Dunbar 2005: 556–557.

90 Our full understanding of the details of this procedure requires additional technical background discussed with the introduction of further material in chapter three below.

91 Dunbar 1995: 551.

92 Plutarch *Nicias* 13.7–8; Plutarch *Alcibiades* 17.5–6; Aelian *Miscellany* 13,12.

93 For a review of the notion that Meton represents Hippodamos, see Castagnoli 1971: 67–69. Von Gerkan (1923: 46–52) rejects the association of Meton's design with anything relevant to the question of surveying and orthogonal planning in the traditions of Hippodamos.

94 See earlier discussion in this chapter.

95 For discussion, see Dunbar 1995: 554–555.

96 Hippolytus *Refutation omnium haeresium* 1.6.3–5; see McEwen 1993: 19 and 139 n. 37, Hahn 2001: 177–218.

97 Evans 1998: 56.

98 Dicks 1971: 172.

99 See Dicks 1971: 84–85; Evans 1998: 39–40.

100 For the relationship between *polis* and cosmos in the *Timaeus*, see Adams 1997. Even the term *demiourgous* for the divine craftsman, with its roots in the *deme* and *ergon*, may connote a civic functionary in addition to an artificer; Adams 1997: 57. For the city as an imitation of the cosmos in the *Statesman*, *Critias*, and *Laws*, see Voegelen 2000: 257–260.

101 For excavations of this early phase (Pnyx I), see Kourouniotes and Thompson 1932; Dinsmoor 1933. For the history of excavations on the Pnyx, see Calligas 1996.

102 Built in 433/2 B.C., foundations 5.85 × 5.10 m; see Kourouniotes and Thompson 1932: 207–211; Travlos 1971: 460; Dunbar 1995: 554–555.

103 Pnyx III dates to 404/3 B.C., increasing seating capacity to about 6,000; see Calligas 1996: 3.

104 See Beare 1906: 12, 44–47; Lindberg 1976: 3–4, 13.

105 Goldhill 1998: 106–107; Taplin 1999: 53.

106 Xenophon gives a clear account of voting procedures in the Ekklesia regarding an incident of 406 B.C., when all tribes vote by dropping a stone in one of two urns, thereby putting on display their vote (*Hellenica* 1.7.7–35); see Sennet 1994: 33.

107 The latest possible date of 456 for the invention of *skenographia* is indicated by Vitruvius' statement that Agatharkhos constructed it and wrote a commentary on it at the time when Aiskhylos, who died in 456, was presenting a tragedy (7.praef.11). For the alternative possibility that Agatharkhos may have worked and wrote in the 420s, as well as the drawbacks of this proposal, particularly the impossibility that Agatharkhos could have influenced Anaxagoras and Demokritos' writings on perspective as per Vitruvius, see Pollitt 1974: 244–245. For the connections between Agatharkhos, Anaxagoras, and Demokritos, see Tanner 2006: 169–170.

108 For the application of less systematic approaches to linear perspective in vase painting preceding Agatharkhos, however, see Richter 1970: 26–28.

109 If we insist on evidence for one-point linear perspective in vase painting, even this has now been demonstrated in vases from Magna Graecia dating back to the fourth century; see Christensen 1999.

110 *Contra* Richter 1970: 52–53. For this idea, see Beyen 1939; White 1987: 51; Keuls 1978: 65.

111 See Chapter 1.

112 For a discussion of this and the following passages in this section, see Halliwell 2000: 107–108; Senseney and Finn 2010.

113 Goldhill 2000: 174–175.

114 For the education of *theatai*, see Goldhill 2000: esp. 175.

115 For an exploration of the relationship between Plato and drama, see Blondell 2002; Puchner 2010, esp. 3–36.

Chapter Three. The Genesis of Scale Drawing and Linear Perspective

1 For whitewashed tablets, see Orlandos and Travlos 1986: 167. Regarding papyrus, surviving examples from the Middle and New Kingdoms do not exceed approximately 45 cm in height, which would place a severe limitation on both reduced-scale and 1:1 drawing; see Coulton 1977: 53.

2 Haselberger 1980: 192; Haselberger 1991: 103.

3 Haselberger 1980; Haselberger 1983a; Haselberger 1983b; Haselberger 1991.

4 For dating, see Haselberger 1980: 205.

5 See Haselberger 2005: 104–107. Vitruvius 3.3.13 provides the Greek term entasis.

6 Sixth-century examples: "Basilica" at Paestum (Mertens 1993: 17), Olympieion in Athens (Korres 1999: 98–101), and Artemision at Epheses (Hogarth 1908: 272); see Haselberger 1999a: 25, 31; Haselberger 2005: 150 n. 28.

7 For an excellent discussion of the character, development, and historiography of entasis, see Haselberger 1999a: 24–32. On the related issue of lifelike qualities in art as an interest for Plato, see Halliwell 2000: 102.

8 Haselberger 1999a: 28.

9 For the Attic foot of .294 – .296 m, see Wilson Jones 2000b: 75 and n. 16 for studies cited.

10 See Haselberger 1980: 201 with n. 33a, crediting this realization to Wolfram Koenigs.

11 Korres (1999: 101) proposes the procedure's application at the Parthenon.

12 For sixth-century examples (Temple of Apollo at Korinth of ca. 550, Siphnian Treasury at Delphi of 525, rebuilt Temple of Athena Polias of 520–510, Temple of Aphaia at Aigina of late sixth century) and bibliography, see Haselberger 2005: 118–119.

13 See Haselberger 1999a: 56–67 for a discussion of this ancient problem of "essence and appearance."

14 On Athenian influence, see Mertens 1984a: 204–205.

15 Mertens 1974; Mertens 1984a: 34–35 with Plate 33 and Beilage 21. These cross-marks divide the fronts into eight sections of 3.280–3.285 m, and therefore eight sections of 10 Doric feet across the euthynteria's total width of 80 feet. The flanks divide into eighteen sections of 3.393–3.405 m. On the Doric foot used at Segesta, see Mertens 1984a: 44–45.

16 For a complete and thoroughly documented discussion of the "the scholarly quest for *scamilli inpares*" from the Renaissance to the present and a consideration of alternative explanations, see Haselberger 1999a: 36–56.

17 Mertens 1974; Mertens 1984a: 34–35. The difference between a catenary and a parabola is negligible. Earlier, Oscar Broneer proposed the catenary as the basis for both horizontal curvature and entasis following his investigations at the fourth century South Stoa at Corinth; see Broneer 1949; Broneer 1954: 91–93.

18 Mertens 1984a: 34–35 with Plate 33.

19 This demonstration rests on a computer-based quantitative evaluation of the parameters of coordinates, determining ellipses as the optimal conic sections that describe the curvature at both Segesta and the Parthenon; see Seybold 1999.

20 Haselberger and Seybold 1991; Haselberger 1999a: 52–54; Haselberger 1999b: 183–184. The division of a chord into eighteen equal segments may be achieved relatively simply by halving the chord and, with a pair of dividers, dividing each half into three segments, each with three subdivisions.

21 "Rund 1 ½ Metern" based on the optimally fitting curve according to Seybold in Haselberger and Seybold 1991: 179; Haselberger 1999b: 184 n. 34 with Figure 9.9. These numbers must be considered approximate, since Haselberger took the values of the ordinates like .086 m by measuring from a scale graph from Mertens 1984a: Beilage 21, Figure B (lengthwise 1:400, but vertically 1:2, with the latter forming the measurements taken by Haselberger). The inexactness of the ordinates makes for an inexact calculation of the theoretical working drawing's radius on purely mathematical grounds. Seybold (1999: 109–110) calculates a radius of ca. .916 m, but the large mean deviation requires a significant shift of the y-axis to a location ca. .45 m east of the center along the euthynteria, resulting in a revised radius of ca. 1.270 m for the theoretical drawing. Yet shifting the y-axis in this way divorces the cross-marks from their proposed function of establishing curvature with a maximum rise in the center. Given the inexactness of the ordinates, therefore, the calculation may serve to demonstrate that the optimal curvature conforms well to an ellipse, but the coordinates provided by the cross-marks should be deferred to in reconstructing the working drawing's radius. This latter solution is that found in Haselberger 1999b: 184 n. 34 with Figure 9.9.

22 Haselberger 2005: 116. For the procedure at work for entasis in the Parthenon, see Korres 1999: 94–101.

23 See Mohr 2005: 14–15, 54–60 and Chapter 1 in this book.

24 For Plato's terminology and sample passages, see Mohr 2005: 248–249; Nehamas and Woodruff 1995: xlii-xliii. See also Chapter 1 of this book.

25 In a related way (though not directly associated with measurement and proportion), Plato also criticizes "shadow painting" (*skiagraphia*): *Republic* 523b; *Phaedo* 69b;

Theaetetus 208e; *Parmenides* 165c; *Critias* 107 c-d; see Bianchi-Bandinelli 1968; Pollitt 1974: 1974: 22–52, 217–224; Keuls 1974; Demand 1975; Keuls 1978: 72–75, 118–119; Rouveret 1989: 24–26, 50–59.

26 See Chapter 1 and its supporting Excursus for the discussions on these elements of planning in Greek building and relevant passages in Plato.

27 See, for example, Plato's association between philosophy and painting (*Republic* 500e–501c), in which the philosopher-rulers employ a divine *paradeigma* in the manner of painters; here, no mention is made of architects.

28 Kirk and Raven 1962: 248–249. See chapter one and its supporting excursus.

29 For Plato's account of numbers in the *Republic* and *Philebus*, see Mohr 2005: 229–238.

30 *De architectura* 3.5.14. As Haselberger discusses (1983: 96 n. 21), *stria* here likely refers to the fillets rather than the channels. For linguistic considerations, see also Howe and Rowland 1999: 211.

31 This consideration need not preclude additional adjustments in the blueprint. In addition to lines suggesting "false starts" in finalizing locations such as those at i′, k, f, f′, and f″, there are creative departures from the guiding geometry in working through the torus moldings of the base at full scale; see Haselberger 1980: 193–198 with Figs. 2 and 3. Both in the final blueprint and the hypothetical reduced-scale drawing to produce it, such alterations can take place through erasure by covering them with chalk and beginning again.

32 Further integral relationships in plan include the 3:7 relationship in the breadth and length of the euthynteria and the 3:8 relationship in the breadth and length of the colonnade axes; see Mertens 1984a: 214, Table C.

33 See Mertens 1984a: 204; Haselberger 2005: 116.

34 Gruben also demonstrates a similar method in the construction of the capitals according to the principle of the circumscribed, right-angled triangle in the Archaic Artemision at Ephesos, as well as in the Late Classical period capitals of the Mausoleum at Halikarnassos; see Gruben 1963: 126–129.

35 Senseney 2007: 574–591.

36 Galen *De Placitis Hippocratis et Platonis* 5.48

37 Philon Mechanikos *On Artillery* 50.6.

38 Haselberger 1980: 203–205 with Beilage 1.

39 Bergama Inv. No. 387; Haselberger 1980: Plate 89.

40 Bergama Inv. No. 2323.

41 For materials of the second century in the area of the stoa, see Shoe 1950: 351.

42 As in, for example, the radial pattern drawn in graphite over the ancient markings on the lower column and base (Delphi Inv. No. 8611) from the Corinthian columns attached to the interior wall of the sekos of the tholos of ca. 380 in the Sanctuary of Athena Pronaia at Delphi (Figure 38), restored in 2004. I thank Sotiris Raptopoulos of the Delphi Archaeological Museum for discussing this restoration with me.

43 The fluting of the neighboring column's capital continues through to the bottom. For comparison with another Roman example of this technique of creating the fluting on the curved outer surface, see the unfinished column shaft with its marks for fluting at the Central Baths in Pompeii; Wilson Jones 1999: 248–249 with Figure 13.23.

44 For the transfer of the blueprint's construction marks to columns visible on site at Didyma, see Haselberger 1980: 204.

45 Concentric, radial designs go back to the earliest traditions of vase decoration from the Minoan Pre-palatial period (3200–2600) and, most prominently, are found in works like the terracotta flask with a belly filled with an eight-petal rosette, circles,

and radial triangles from the Final Palatial period of 1400–1350 (Heraklion Inv. No. 9039). From Helladic traditions such designs continue through the Geometric period and beyond, finding monumental expressions in the Archaic period in the architectural acroteria at Olympia, for example.

46 From as early as ca. 600–560, stone columns of the Ionic order feature twenty-four flutes, but other contemporary examples feature anywhere from twenty-seven to forty-four flutes. The canonical fillets rather than arrises that characterize earlier Ionic capitals make their earliest known appearance with the Polykratean Heraion at Samos, begun ca. 530; Barletta 2001: 98.

47 As in Howe and Rowland 1999: 211 with n. 32 and 210 with Figure 53. Howe also suggests the possibility of beginning with a hexagon and gradually halving its six sides. It is unclear that craftsmen working on columns (as opposed to architects who created models for them) would have readily known a method that constructs a precise hexagon, however. Furthermore, the process would be cumbersome compared to the kind of measurements and procedure provided by something like the blueprint at Didyma, for example.

48 A set of recognizably Doric capitals from a number of sites dating from the late seventh to early sixth centuries comprises our evidence for the emergence of the Doric order during that time over the span of about two generations; see Barletta 2001: 54–63. In most of these examples, the flutes on the shaft extend to the necks. Frequently, they feature sixteen rather than twenty flutes, though this tendency may relate to the smaller size of some examples rather than a chronological development, and indeed already in ca. 580–570 the capitals of the Temple of Apollo I at Aigina feature twenty flutes. Barletta notes the connection between the use of sixteen flutes and traditional Egyptian practices that may have been influential, as well as the ease of subdividing a circle into sixteen parts.

49 Gros 1976a: 688 with n. 4 and Figure 6.

50 To take the hypothetical example of a drum with a diameter of 1 m: Corresponding to Figure 75.1, we may find AB by $AC - CO$, with AC found through the Pythagorean theorem. $CO = 25$ cm and $AO = 50$ cm. $25^2 + 50^2 = AC^2$, therefore $AC = 55.902$ cm. 55.902 cm $- 25$ cm $= 30.902$ cm $= AB$. $AB/2 = 15.451$ cm, equal to a difference of 2.57 mm from 15.708 cm, and a cumulative difference of 5.18 cm (!) in the circumference of 3.0902 m from 3.142 m, or 1.65%. This proposed geometric formula, therefore, does not approach the precision necessary to flute a column.

51 Ito 2004: 138 with n. 14. As in the previous note, we may test this proposal with a hypothetical drum of a diameter of 1 m. 5/16 of the radius of 50 cm is 15.625 cm, compared to 15.708 cm, which is 1/20 of the circumference of 3.142 m. The circumference would be 3.125 m, equal to a cumulative difference of 1.66 cm from the circumference of 3.142 m, or 0.55%. This arithmetical formula is therefore acceptable.

52 Bergama Inv. No. 2323.

53 In addition, there are other possible techniques of executing these radial divisions on a curved ruler by way of the compass and straightedge. On the shield of the Roman marble copy of the "Dying Gaul" from Pergamon or Delphi (220s BC) in the Capitoline Museums in Rome, for example, is a geometric diagram incised into the marble. According to the analysis of Miriam Finckner, the drawing preserves the process for constructing a circumscribed pentagon. The completion of the chords on this drawing would create a twenty-sided polygon, which may demonstrate an ancient method of radially constructing such a figure that can conceivably apply to the present question of producing a protractor for Doric fluting. The individual circumferences are broken and of inconsistent diameter, and do not always coincide

with the lines with which they are intended to intersect. As has been reasonably explained, these imperfections likely result from having been transferred to the marble copy by means of a tracing device, followed with the application of a compass by a copyist who did not understand the subtleties of the figure's geometry; see commentary of Finckner in Coarelli 1995: 49. Coarelli (1995: 29–31) proposes that the principle axes of this geometric form guided the composition of the sculptural group of the Dying and Suicide Gauls (Palazzo Altemps, Rome) that stood together on the circular monument of Attalos I in the sanctuary. Coarelli (1995: 37–41) further argues that the same geometry may have governed the architectural composition of the sanctuary as a whole. See also Senseney 2009.

54 For alternative techniques, see Haselberger 1999a: 36–56.

55 Although *among* the earliest, these divisions along the perimeter of column shafts were unlikely to have been *the* earliest modules in Greek architecture, which more probably are to be identified with roof tiles. Because flutes as perimetric modules were created through procedures of drawing, however, they were arguably of the most profound influence for the development of modularity in ichnography. For the role of terracotta tiles in the development of modularity in Protocorinthian temple roofs going back to the "Old Temple" of the seventh century at Corith (as opposed to the Temple of Apollo of the sixth century), see Sapirstein 2009: 222–223. For the fluting of Doric columns as early as the seventh and early sixth centuries, see Barletta 2001: 54–63.

56 Gros 1976a: 688.

57 See Chapter 2.

58 Hippolytus *Refutation omnium haeresium* 1.6.3–5. See McEwen 1993: 9–40; Hahn 2001: 177–218.

59 The earliest surviving testimony for Anaximander's earth as column drum is Hippolytus, writing in the third century A.D. (*Refutation omnium haeresium* 1.6.3–5).

60 See, for example, Berryman 2009: 6–7.

61 Goldhill 2000: 174–175.

62 The method of graphically producing this arrangement, suggested by Rakob (1976: Beilage 21) and supported by Gros (1976a: 94), is, however, faulty; see earlier discussion.

63 For the dates associated with Hermogenes' works and career, see Kreeb 1990. For the sanctuary and its relationship with its larger architectural environment, see Humann, Kohte, and Watzinger 1904: 107–111, 130–141; Wycherly 1942: 25–26; G.E. Bean in Stillwell 1976: 554–557; Coulton 1976b: 253.

Chapter Four. Architectural Vision

1 Wallace-Hadrill 2008: 147.

2 Based on the translation of Rowland, in Howe and Rowland (1999: 47), with slight modification.

3 For Leonardo's adjustments, see Wilson Jones 2000b: 81–84 with Figure 8; Wesenberg 2001. In a recent analysis, McEwen (2003:155–160) stresses that early modern images like that of Leonardo did not have a precursor by the hand of Vitruvius, for whom the idea of this recumbent human form was just a textual description unaccompanied by an illustration of the type provided for Book 3's reference to the construction of entasis (3.1.3), horizontal curvature (3.4.5), and an Ionic volute (3.5.8). This lack of an illustration has no bearing on the present discussion, since my purpose here is to analyze precisely Vitruvius' description of his drawing for what it may impart to our understanding of traditions of Hellenistic ichnography.

McEwen relates Vitruvius' discussion of geometry and the body in this passage to practices of augury – an idea that is interesting but without direct support in Vitruvius' commentary. The analysis here maintains the Vitruvian man's specified role as an analogy between temples and the human body in a discussion of temple of design by way of the original Greek terminology that describes it. For illustrations in Vitruvius, see Gros 1988: 57–59; Haselberger 1989; Haselberger 1999: 28, 36; Haselberger 2005: 116.

4 McEwen 2003: 181–182 is clear in connecting the Vitruvian man with ichnography specifically.

5 Slightly modified Loeb translation of H.L. Jones (1929: 89). Strabo here quotes Demetrios' accound of Attalos' description.

6 These philosophers include the founder of the Middle Academy Arkesilaos from Pitane, Telekes from Phokaia, Evander from Phokaia, and Hegesinos from Pergamon; see Hansen 1971: 396.

7 On visuality, see Jay 1988: 16–17; Bryson 1988: 91–92; Elsner 2000 and 2007: xvii.

8 Translation of Rowland, in Howe and Rowland 1999: 47.

9 Translation of Rowland, in Howe and Rowland 1999: 47.

10 Translation of Rowland, in Howe and Rowland 1999: 24, with slight modification.

11 For Vitruvius' emphasis on *taxis* and *diathesis* both as active processes rather than completed products, see Scranton 1974: esp. 496–497.

12 Compare with Plato's statements that a work's beauty and virtue depend on measure and *symmetria* that define its *taxis* in its constitutive parts: *Philebus* 64e, *Republic* 444e. Compare also *taxis* with Plato's οἰκεῖος κόσμος (*Gorgias* 506d); see Maguire 1964; Maguire 1965: 171–172 with n. 3. On the interchangeability of beauty and truth in Plato, see Maguire 1965: 180–182.

13 Translation of Rowland 1999: 24.

14 Based on the translation of Rowland 999: 25, with slight modification.

15 The Greek origins of this idea are underscored by Vitruvius' reference to the Greek term when discussing quantity.

16 *De architectura* 1.2.3. For Plato, *eurythmia* (*Republic* 400e) allows the craft of building along with music, dance, poetry, painting, and embroidery to imitate the Ideas (*Republic* 400e–402b).

17 Aristophanes makes the distinction clear in his *Clouds* (638–641). In one passage of the comedy, Sokrates cannot make Strepsiades understand the concept of meter in its poetic rather than everyday sense. The humor of the scene arises from Sokrates' subsequent suggestion that perhaps Strepsiades should learn about rhythm instead, which of course is absurd for anyone who cannot understand meter.

18 McEwen 2003: 157 asserts this view by contrasting Vitruvius' "how-to" passages with the geometry underlying architectural features like entasis and Ionic volutes.

19 Translation of Rowland, in Howe and Rowland 1999: 47.

20 McEwen 2003: 157.

21 On Vitruvius' education and liberal arts background, see Howe in Roland 1999: 7–8, 14–17. Regarding his command of Plato, see de Jong 1989: 101–102; Senseney 2007: 561–562.

22 Hermodoros is cited in Cicero *De oratore* 1.14.62; Priscian *Institutiones grammaticae* 8.17.4 (quoting Cornelius Nepos); Vitruvius *De architectura* 3.2.5. The classic study on Hermodoros and his influence on Vitruvius is Gros 1973. See also Gros 1976b. Recent studies summarizing the current conclusions and hypotheses concerning Hermodoros include Müller 1989: 158–159; Anderson 1998, 17–19; Wilson Jones 2000b: 20.

23 This understanding is consistently corroborated throughout several passages of the *De architectura* as well as Cicero (*Epistulae ad Atticum* 2.3). See Haselberger 1999: 56–58.

24 Again, most recently, see Haselberger 1999: 59–60 and earlier studies cited.

25 Inscription: von Gaertringen 1906: 143, no. 207. English translation of Coulton 1977: 70–71.

26 *De architectura* 3.2.6, 3.3.8, 4.3.1, 7.praef.12. For arguments against an easy identification of the Hermogenes of the inscription with the Hermogenes of Vitruvius, see von Gerkan 1929: 27–29.

27 As in the outline of footprints (Aiskhylos *Libation Bearers* 209); Liddel et al. 1940: s.v.

28 In this regard, compare Plato's metaphorical use of the term (*Republic* 504d, 548d; *Laws* 737d); Liddel et al. 1940: s.v.

29 See Coulton 1977: 71. The other inscription referencing *hypographai* comes from Delos; see Dürrbach 1926: 41.

30 Haselberger 1997: 92 discusses how plans in antiquity functioned as symbols of the buildings, "likenesses," found in dedications, votives, and funerary objects, and accordingly frames the *hypographe* from the Priene inscription as a votive offering.

31 *De architectura* 6.1.1. Translation of Rowland 1999: 56.

32 *De architectura* 3.3.13; 4.4.2; 6.2.1; 6.3.11

33 For a discussion of the possibility of ichnography in the design of earlier temples, see Chapter 1. Despite his skepticism about ichnography in Greek temple design, Coulton (1977: 71 n. 67) allows for the possibility of its application in the Temple of Athena Polias at Priene. Coulton interprets Vitruvius' comments about the importance of architectural drawing and the beliefs of Pytheos (*De architectura* 1.1.12–13) as an indication that such practices may in fact date back to Pytheos, to whom Vitruvius attributes the temple's design. The original archaeological study and restoration of the temple by Wiegand and Schrader (1904: 81–135 with Plate 9) already recognized the modular underpinning of the ground plan, based on a module of six feet of .295 m expressed by the plinths. More recent major studies of the temple with important discoveries and observations concerning its design are by Koenigs (1983 and 1999). For an interesting proposal for Pytheos' role in designing the larger urban context of Priene, see Hoepfner and Schwandner 1994: 188–225. For additional considerations, see Koenigs 1993; Gruben 2001: 416–423.

34 For the relationship between such grids and drawing, see Hoepfner 1984: esp. 21–22.

35 Plinths = 1.77 m, or 6 feet of .295 m; axial distances = 3.53 m; axes of the naos = 10.62 × 28.32 m; axes of the peripteron = 17.67 × 35.34 m; stylobate = 19.47 × 37.17 m; krepis = 21.21 × 38.91 m.

36 Koenigs 1983: 165–68, with drawing by J.M. Misiakievicz in Figure 1 and photograph in Plate 44.1.

37 Haselberger 1980: 192; Haselberger 1991: 103.

38 For the drawing at Didyma, see Haselberger 1983: 98–104 with Figure 2 and Plate 13. For the drawing in Rome, see Haselberger 1994.

39 For the uniqueness of the Athena temple's grid during its period, see Martin 1987: 193–194; Koenigs 1999: 145. De Jong (1988) posits a connection between Pytheos' temple and the Temple of Hemithea at Kastabos of ca. 330 B.C. This connection is based on considerations of proportion and a proposed geometric construction for the diameter of the columns related to the formula $\sqrt{3} - 1$. This suggested relationship between the column diameters and this geometric process of design is

difficult to accept. Also, the proportional relationships found at Kastabos are quite different from Pytheos' system because they pertain to the spaces between the walls rather than the axes of the walls. The plan, therefore, was likely worked through without a graphic component like a grid or any other geometry, and likely shows no relationship to reduced-scale drawing. For the temple at Kastabos, see Cook and Plommer 1966.

40 For the by now well-substantiated dating of Hermogenes' works and career and a thorough consideration of the evidence, along with earlier arguments for later dates, see Kreeb 1990.

41 For mention of these lost writings of Pytheos and Hermogenes, see Vitruvius 1.1.12, 3.3.1, 7.1.12.

42 The temple at Teos is a Roman restoration that presumably reflects the original ground plan by Hermogenes, although its faithfulness cannot be certain. For the Roman fabric, see Mustafa Uz 1990. For an assessment of de Jong's (1989) geometric analysis of the temple, see Senseney 2009: 40–42.

43 As Coulton 1977: 71 suggests.

44 Widened from 3.94 m to 5.25 m; Humann 1904: 39–49, with state and restored plans in Figs. 29, 30.

45 See Hoepfner 1990: 2–3.

46 Vitruvius 1.2.2. Translation of Rowland 1999: 25.

47 As essentially stated by Onians 1979: 165–166.

48 See Koenigs 1983: 141–143; Koenigs 1984: 90.

49 This diversion is in addition to the wider axial distance of 5.25 m along the temple's central axis, discussed earlier. See Humann 1904: 39–49.

50 The horizontal curvature along the flanks of the three-stepped krepis rises ca. 4 cm. The toichobate curvature varies between 1.5 and 2.2 cm. The maximum deviation in the entasis of the columns is ca. 2 cm. There are very slight variations in the levels of the four corners of the Athena temple, but Koenigs (1983: 89–90, 1999: 143–145) attributes these to slight mistakes.

51 See Müller 1990: 21–34.

52 See, for example, the progressive development of Bramante's ichnography for St. Peters in 1505–1509: Miller and Magnago Lampugnani 1994: cat. nos. 280, 283, and 288 (Uffizi 8A verso and 3A recto); Fromel 1994: 112. For the function of the grid in actual planning as opposed to polished "presentation drawings" for patrons (as observable in a comparison between Bramante's Uffizi A 1 and the recto of Uffizi A 20), see Huppert 2009: 161–162. Regarding this distinction, Filarete in particular separated "disegno in grosso" from "disegno proporzionato," or a drawing with a superimposed grid scaled for *braccia*; Tigler 1963: 154–157.

53 "Triglyphs must of necessity be placed in line with the center axes of the columns . . . " (Vitruvius 4.3.2). Translation of Rowland 1999: 57.

54 Wilson Jones 2000b: 64–65; Wilson Jones 2001.

55 Vitruvius 4.3.1. Translation of Rowland 1999: 57. For Vitruvius' close adherence to the traditions of Ionic design advocated by Hermogenes, see Tomlinson 1989.

56 For arguments against the commonly held notion of a decline of the Doric order in the Hellenistic period, see Tomlinson 1963.

57 Senseney 2007.

58 Vitruvius 3.3.1-8, followed by a discussion that considers columnar heights in conjunction with their diameters and intervals.

59 As essentially argued by Bundgaard 1957: esp. 93–96, 113–114.

60 For a discussion of *paradeigmata* and *syngraphaphai* and scholarly sources, see Chapter 1.

61 For the sanctuary and its relationship with its larger architectural environment, see Humann, et al. 1904: 107–111, 130–141; Wycherly 1942: 25–26; G.E. Bean in Stillwell 1976: 554–557; Coulton 1976b: 253.

62 Hoepfner 1990: 18. Elsewhere, in the second century B.C., the agora at Athens received two new stoas on the south side, as well as the Stoa of Attalos on the east side, all of which were oriented according to the cardinal points. In addition, sight lines from the Hephaisteion and Metroon cross at the Bema in front of the Stoa of Attalos; see Onians 1979: 165–166.

63 Hoepfner 1997: 111–114, also with his Figure 1a suggesting the possibility that the Artemision and agora may have been composed according to sight lines.

64 The main publication on the Koan Asklepieion's archaeology is Schazmann and Herzog 1932. For a complete study of Temple A and its date, see Schazmann and Hergog 1932: 3–13, Figs. 3–14, Pls. 1–6. For the sanctuary's history, see Sherwin-White 1978: 340–342, 345–346. For a detailed study of the ornament of Temple A, see Shoe 1950. For the design process underlying Temple A's form, see Petit and de Waele 1998; Senseney 2007: 570. For an analysis of the design of the sanctuary as a whole, see Doxiadis 1972: 125–126 and criticism in Senseney 2007: 566.

65 See Senseney 2007; Senseney 2010.

66 Equal to 1.515 m. The irregular spacing of the columns on the flanks results in slight imperfections in the intended uniform length of the column-supported paving slabs, varying by only half a centimeter (1.510–1.515 m) in the three surviving slabs on the western edge of the stylobate. In turn, these variations affect another slight variation preserved in the two surviving axial distances in the western pteron (3.034 and 3.05 m). To correct these irregularities, the temple's excavators posit theoretical magnitudes of 1.515 m for the slabs and 3.050 m for the axials. Other imperfections include divergences in the thickness of the eastern and western walls of the naos (1.028 and 1.016 m, respectively) and distances from the eastern and western walls to the outer edge of the euthyteria on either side (4.368 and 4.435 m, respectively). This latter asymmetry of 0.067 m on either side of the naos is clearly not intended in the temple's design. As I have demonstrated elsewhere through three separate sets of calculations, the three plausible corrections to this irregularity are too slight to affect a proper geometric analysis of the temple's plan; see Senseney 2007: 588–593. Whereas the excavators posit the irregularity's cause to be an earthquake that shifted the entire naos, a slight error in the construction itself may be responsible.

67 Total width of 18.142 m: 1.515 m × 12 = 18.18 m, a difference of 3.8 cm, or 0.2%. Total length of 33.280 m: 1.515 m × 22 = 33.33 m, a difference of 5.0 cm, or 0.15%.

68 Smaller circle: radius of 9.0615 m. 1.515 m × 6 = 9.09 m, a difference of 2.85 cm, or 0.3%. Larger circle: radius of 15.1235 m. 1.515 × 10 = 15.15, a difference of 2.65 cm or 0.2%. For Pytheos' Temple of Athena Polias at Priene, see earlier discussion in this chapter.

69 See Chapter 3 and Appendix A.

70 For the dating of the sanctuary by the inscription on its altar, see Coarelli 1982. For the following analysis and interpretation of the temple and its architect, see Almagro-Gorbea 1982; Jiménez 1982, esp. 63–74; Almagro-Gorbea and Jiménez 1982. See also Coarelli 1987: 11–21.

71 For the theater-like arrangement, see Jiménez 1982: 61–63.

72 Almagro-Gorbea and Jiménez 1982: 121.

73 See Morricone 1950: 66–69, figs. 13, 14, 16, 17. As in the case of the Asklepieion's upper terrace complex, the harbor sanctuary's marble and tufa architectural remains are scanty, but enough survive for an archaeologically based reconstruction of the original plan. Built on a ca. 2.5 m high artificial platform (ca. 62.40 by 45 m in overall plan), a complex of Doric porticoes encloses a ca. 33 by 38 m central colonnaded space open to the sky.

74 For the excavations, see A. Viscogliosi in *LTUR* 1993–2005: 130–132.

75 For the influence of the Porticus Metelli on the Imperial Fora, see Kyrieleis 1976.

76 Wilkinson 1977: 124–126.

77 For linear perspective in the Renaissance architectural design process, see Huppert 2009.

78 Translation of Rykwert et al. 1988: 34.

79 Compare with the opening lines of Book One of Alberti's *On Painting* of 1435–1436: "To make clear my exposition in writing this brief commentary on painting, I will take first from the mathematicians those things with which my subject is concerned. . . . In all this discussion, I beg you to consider me not as a mathematician but as a painter writing of these things. Mathematicians measure with their minds alone the forms of things separated from all matter. Since we wish the object to be seen, we will use a more sensate wisdom." Translation of Spencer 1966: 43.

80 Marsiglio Ficino, *Sopra lo amore o ver convito di Platone* (Florence 1544), Or. V, ch. 3–6: 94–95. See Introduction in this book.

81 For Plato's criticism as a provocation for painters to use mimesis to express instrumental rather than intrinsic value (as opposed to the traditional interpretation that Plato rejects the value of painting and mimesis outright), see Halliwell 2000: esp. 110.

82 For Manetti's account and Brunelleschi's development and demonstration of linear perspective, see Wittkower 1953; Gadol 1969: 25–32; Lindberg 1976: 148–149; White 1987: 113–121.

83 See Halliwell 2000 and discussion in Chapter 2 of this book.

84 For a fascinating look at the role of drawing in the continuity of Michelangelo's creation as an architect with his work as a painter and sculptor, see Brothers 2008.

Excursus: Envisioning Cosmic Mechanism in Plato and Vitruvius

1 Kirk and Raven 1962: 248–249. See also Pollitt 1974: 18. For an interpretation of continuity between Pythagorean traditions and Plato through a thematic connection of mathematics and war, see Onians 1999: 30–50.

2 Aristotle *Metaphysics* 1092b8. For additional sources, see Kirk and Raven 1962: 313–317. For the possible suggestion of the third dimension in Eurytos' planar representations, in my opinion unlikely, see Pollitt 1974: 90 n. 14.

3 I thank Richard Mohr for suggesting the possible importance of Plato's reference to Daidalos' diagrams for the question of architectural drawing.

4 Elsewhere for Plato, measure and commensuration constitute beauty and virtue in the work (*Philebus* 64e, *Republic* 444e). See earlier discussion.

5 See Pollitt 1974: 14–22. According to ancient sources, however, κανόνες are usually straightedges rather than instruments for measuring dimensions; see Coulton 1975: 90. On the importance of measure and balance for thought in the fifth century in particular, see Politt 1972: 3–5.

6 This is the conclusion of Pollitt 1995: 19–20. According to Galen (Kühn editions of *De Temperamentis* 1.566 and *De Placitis Hippocratis et Platonis* 5.48), Polykleitos titled both his treatise and his statue "Canon."

7 Plutarch mentions Kallikrates along with Iktinos as an architect of the Parthenon (*Pericles* 13), whereas Ausonius (*Mosella* 306–309), Strabo (9.1.12 and 9.12.16), and Pausanias (8.41.9) mention only Iktinos. I therefore follow others in identifying Iktinos as the temple's designer. For this view, see Coulton 1984: 43; Hurwit 1999: 166; Gruben 2001: 173; Korres 2001a: 340; Korres 2001b: 391; Schneider and Höcker 2001: 118; Barletta 2005: 95; Haselberger 2005: 148 n. 10. For the sources and arguments concerning Iktinos, Kallikrates, and Karpion, see also Carpenter 1970; McCredie 1979; Svenson-Evers 1996: 157–236; Gruben 2001: 185–186; Korres 2001a, 2001b, 2001c; Barletta 2005: 88–95.

8 Lauter 1986: 27–28. On Vitruvius' dependence on Greek theory, see Wallace-Hadrill 2008: 145–147.

9 For the sculptural careers of Greek architects, see Pollitt 1995: 20 and n. 12.

10 Pollitt 1995: 20.

11 This and all subsequent references to Philon's treatise cite the edition of Marsden 1971.

12 Andrew Stewart follows earlier writers in positing *para mikron* as "from minute calculation"; see Stewart 1978: 126, along with a review of the four classic possible meanings.

13 For this conclusion and penetrating supporting analysis, see Philip 1990: 137–139. I strongly support Pollitt's 1995: 21–22 similar interpretation, which offers architectural design process as means of understanding *para mikron*. Citing observations on the working drawings on the adyton wall of the Didymaion (Haselberger 1985), the intuitive departures from the geometric basis of design characterize the same approach to intuitive adjustment. Haselberger 1999: 66–67 remains ambivalent about how much the statement might truly reflects Polykleitos' views, focusing instead on its value for Philon's views in the third century.

14 Studies that interpret a Pythagorean basis for Polykleitos' views include Raven 1951; Pollitt 1974: 17–21; Stewart 1978; Pollitt 1995.

15 To be clear, I intend that, despite this departure, the origins of this idea in Polykleitos' theory may have very well been Pythagorean sources. Pollitt eloquently argues the possibility that the phrase (τὸ εὖ), as it is used in the context of Aristotle (*Metaphysics* 1092b26) and Plato (*Timaeus* 68e), appears to demonstrate Pythagorean origins. I would emphasize, however, that Polykleitos' possible departure from the doctrine is tantamount to a departure from Pythagorean philosophy.

16 Similarly, Schulz 1955 analyzes Plutarch's description (*Moralia* 45c-d) of καιρός as an intuitive or chance result rather than a product of numbers and connects this idea with the meaning of παρὰ μικρόν, though this reading does not really work for Plutarch's passage; see von Steuben 1973: 50–53; Stewart 1978: 126.

17 As is apparent in Chapters 2 and 3, the reference to painting here may be an important clue as to the nature of the kind of diagrams Plato likely refers to.

18 However, for a distinction between proper and misused mimesis (as opposed to inherently bad mimesis) in the realm of painting, see Halliwell 2000.

19 The following account of the process of sculptural creation is that of Bluemel 1969: 34–43. On the use and necessity of models and molds in Greek marble sculpture in the Archaic and Classical periods, see also Palagin 2006: 243–244, 262–264.

20 The earliest explicit reference to Daidalos as an architect is by Apollodoros (3.15.8,6) in the second century, where Daidalos is credited for the labyrith. See Morris 1992: 190. As Morris observes, however, Apollodoros' description of the labyrinth seems to reflect that of Sophokles in the fifth century (Nauck, fragment 34), which may come from his lost drama *Daidalos*. In addition, the black figure painting on the Rayet *skyphos* of the sixth century from Tanagra, Boiotia (Louvre MN 675) shows

Adriadne with Theseus as he slays the Minotaur, the saved youths and maidens of Athens, and a belted (=Cretan?), winged figure in the air that can only reference either Ikaros or Daidalos, thereby linking Daidalos with the architectural setting of the labyrinth already by the Archaic period; see Morris 1992: 190–191 and figs. 10a-10d. For the likely identification of the winged figure with Ikaros (and therefore the link between Daidalos and the labyrinth), see also Beazley 1927: 222–223; Kokalakis 1983: 25.

21 As emphasized by Keuls 1978: 124, the term διάγραμμα normally refers to geometric figures.

22 Ovid (*Metamorphoses* 8.151–8.259) tells of Daidalos nearly becoming lost in the labyrinth.

23 Two centuries later, Galen (ed. Kühn vol. 5, p. 68) echoes Vitruvius in including *gnomice* under the heading of architecture; see Soubiran 1969: x.

24 For this view of Plato as a maker of timepieces, see Mohr 2005: 14–15, 54–60. For additional discussion and references, see further discussion.

25 Despite Vitruvius' differences from Aristotelian teleology, an influence here may nonetheless be Aristotle's *Mechanica*. See Fleury 1993: 324; Berryman 2009: 130–131.

26 . . . *e rerum natura sumserunt exempla et ea imitantes inducti rebus divinis commodes vitae perfecerunt explicationes* (*De architectura* 10.1.4).

27 For the connection between Vitruvius' passage and Plato's divine craftsman, see McEwen 2003: 236. For the influential role of the *Timaeus* during the Late Republic as cited by McEwen, see Griffin 1994: 709. See also the Loeb edition for Vituvius of Granger 1934: 277 n. 6.

28 See Mohr 2005: 18, 56–57 as well as 56 n. 12 for important discussion of Brague 1982: 66. The astronomical views on which Plato bases his dialogue can be attributed to Plato and the astronomers from who he drew influence, among which Timaios, however, is likely just a fictional mouthpiece; see Dicks 1970: 116.

29 For excellent discussion on Anaximander, see McEwen 1993: 9–40. Testimony for Anaximander's constructions: Diogenes Laertius 2.1–2. See Kirk, Raven, and Schofield 1983: 100; McEwen 1993: 17–18. Testimony for Anaximander's writings in the tenth century: Suda s.v. Anaximander. See Kirk, Raven, and Schofield 1983: 101; McEwen 1993: 18–19. Anaximander's own prose survives in the B1 fragment of the commentary on Aristotle's *Physics* of Simplikios from the fifth century. This fragment contains anywhere from seventeen to fifty-six of Anaximander's own words. For analysis and a summary of earlier scholarship on the B1 fragment, see McEwen 1993: 10–17.

30 Hippolytus *Refutation omnium haeresium* 1.6.3–5. Accepting the columnar form of Anaximander's earth are McEwen 1993: 19, and Hahn 2001: 117–218. On the difficulties of interpreting Anaximander's model, see Berryman 2009: 32–33.

31 McEwen 1993: 9–40. Hahn 2001 is largely devoted to this thesis.

32 *De architectura* 7.praef.12–17. In the preface to his fourth book, Vitruvius remarks that previous architectural writers "had left behind them precepts and volumes not set in proper order but taken up instead as if they were stray particles" (translation of Rowland, in Howe and Rowland 1999: 54). McEwen 2003: 236 rightly points out that, in contrast to these earlier writings, Vitruvius appears to be the first to have written a complete corpus on architecture. Still, this probability should by no means suggest that Vitruvius did not draw on an existing tradition of cosmological models scattered throughout earlier architectural commentaries.

33 This connection between weaving and the stars repeats in Euripides (*Helena* 1096).

34 See McEwen 1993: 9, 18, 23–25.

35 Hyppolytus 1.6.3.

36 τῶν δὲ ἀληθινῶν πολὺ ἐνδεῖν, ἃς τὸ ὂν τάχος καὶ ἡ οὖσα βραδυτὴς ἐν τῷ ἀληθινῷ ἀριθμῷ καὶ πᾶσι τοῖς ἀληθέσι σχήμσι φοράς τε πρὸς ἄλληλα φέραται καὶ τὰ ἐνόντα φέρει (Plato *Republic* 529d).

37 Compare with the Loeb translation of Shorey, which inserts "vehicles" to convey Plato's point: "but we must recognize that they fall far short of the truth, the movements, namely, of real speed and real slowness in real number and in true figures both in relation to one another and as vehicles of the things they carry and contain."

38 Morris 1992: 169.

39 The issue of the relative speeds of astral bodies is particularly important to Plato. Compare Plato *Gorgias* 451c, identifying the *logos* of astronomy.

40 On Leonardo's drawings of machines, see Galluzzi 1996; Marinoni 1996; Scaglia 1996

41 For Paconius' vehicle, Vitruvius gives the dimensions of the statue base of Apollo as 12 feet by 8 feet and 6 feet high, enclosed by battens 2 digits wide, and with wheels of a diameter of about 15 feet. Beyond the metric specification of timbers with a width of 4 digits in Metagenes' machine, one surviving reflection of commensurations, like equals and doubles in Vitruvius' account of the Archaic vehicles at Ephesos, is the specification of equal length in the column and crosspieces of the frame in Khersiphron's machine. For Metagenes' machine, Vitruvius' account provides a diameter of about 12 feet for the wheels, though it does not preserve the important dimensions of height and width of the architrave blocks (about 6 feet?) that would make this diameter meaningful for anyone wishing to imitate this vehicle.

Appendix A. Analysis of the Dimensions of the Blueprint for Entasis at Didyma

1 Haselberger 1980: 199.

2 Haselberger 1980: 200.

Appendix C. Analysis of the Hypothetical Working Drawing for Platform Curvature in the Parthenon

1 See Stevens 1943: Figure 1. These seventeen locations correspond to the locations of the columns rather than to evidence for the ancient coordinates in the manner of the cross-marks found at Segesta.

2 Seybold 1999: 108, with all y coordinates in Table 4.2 on 111 given in relation to the first x coordinate at level 0. Compare Stevens 1943: Figure 1.

3 For purposes of calculation, this rise at the y-axis may be considered the maximum rise of curvature, although technically the maximum rise of .1215 m appears to the west of the y-axis in accordance with the higher level of the northwest corner. The negligible difference between these two measures is insignificant for the calculation that follows. In identifying the vertical distance from the central rise to the level of the northeast stylobate as the meaningful measurement, I set aside the alternative measurement of.103 m from the center of the diagonal baseline connecting both corners of the stylobate, which inclines to a point .0175 m above the northeast corner; see Stevens 1943: 137, Figure 1.

4 To quote the term used by Korres 1999: 92.

REFERENCES

References follow the standard abbreviations in the *American Journal of Archaeology*.

Ackerman, J. 2002. "The Origins of Architectural Drawing in the Middle Ages and Renaissance." In *Origins, Imitation, Convention: Representation in the Visual Arts*, pp. 27–66. Cambridge, Mass.

Adams, M.R. 1997. "Environmental Ethics and Plato's *Timaeus*." In *The Greeks and the Environment*. Edited by L. Westra and T.M. Robinson, pp. 55–72. Lanham, Maryland.

Africa, T.W. 1968. *Science and the State in Greece and Rome*. New York.

Akurgal, E. 1973. *Ancient Civilizations and Ruins of Turkey*. 3rd ed. Istanbul.

Alexandrakis, A. and J. Knoblock. 1978. "The Aesthetic Appeal of Art in Plato and Aristotle." *Diotima* 6: 178–185.

Almagro-Gorbea, M. 1982. "Levantamiento fotogramétrico del templo." In *Gabii*, pp. 33–38.

Almagro-Gorbea, M. and J.L. Jiménez. 1982. "Metrologia, modulacion, trazado, y recon struccion del templo." In *Gabii*, pp. 87–124.

Amici, C. 1991. *Il Foro di Cesare*. Florence.

Anderson, J. 1998. *Roman Architecture and Society*. Baltimore.

Anti, C. 1947. *Teatri greci arcaici*. Padua.

Anti, C. and L. Polacco. 1969. *Nuovo ricerchi sui teatri greci arcaici*. Padua.

Arendt, H. 1958. "What Was Authority?" In *Authority (Nomos 1)*. Edited by C.J. Friedrich, pp. 81–112. Cambridge, Mass.

Ball, L.F. 2003. *The Domus Aurea and the Roman Republican Revolution*. Cambridge.

Bankel, H. 1993. *Der spätarchaische Tempel der Aphaia auf Aegina*. Berlin.

Barletta, B.A. 2001. *The Origins of the Greek Architectural Orders*. Cambridge.

———. 2005. "The Architecture and Architects of the Classical Parthenon." In Parthenon, pp. 67–100.

Bartman, E. 1993. "Carving the Badminton Sarcophagus." *MMAJ* 28: 57–71.

Beard, M. 2002. *The Parthenon*. London.

Beare, J.I. 1906. *Greek Theories of Elementary Cognition from Alcmaeon to Aristotle*. Oxford.

Beazley, J.D. 1927. "Icarus." *JHS* 47: 222–233.

Benjamin, W. 1968. "The Task of the Translator." Translated by H. Zohn. In *Illuminations*. Edited by H. Arendt, pp. 69–82. New York.

Berggren, J.L. and R.S.D. Thomas. 1996. *Euclid's Phaenomena: A Translation and Study of a Hellenistic Treatise in Spherical Astronomy*. London.

Bernal, M. 1987. *Black Athena: The Afroasiatic Roots of Classical Civilzation I. The Fabrication of Ancient Greece* 1785–1985. London.

Berryman, S. 2009. *The Mechanical Hypothesis in Ancient Greek Natural Philosophy*. Cambridge.

Beyen, H.G. 1939. "Die antike Zentralperspektive." *AA* 54: 47–71.

Bianchi, R.S. 1997. "An Elite Image." In *Chief of Seers: Egyptian Studies in Memory of Cyril Aldred*. Edited by E. Goring et al., pp. 34–48. London.

Bianchi Bandinelli, R. 1956. "Osservazioni storico-artistiche a un passo del > platonico." In *Studi in Onore di U.E. Paoli*, pp. 81–95. Florence.

Bieber, M. 1961. *The History of the Greek and Roman Theater*, 2nd ed. Princeton.

Birnbaum, A. 1914. *Vitruvius und die griechische Architektur*. Vienna.

Blondell, R. 2002. *The Play of Character in Plato's Dialogues*. Cambridge.

Bluemel, C. 1969. *Greek Sculptors at Work*. New York.

Boëthius, A. 1978. *Etruscan and Early Roman Architecture*. Harmondsworth.

Bousquet, J. 1941. "La colonne dorique de la Tholos de Marmaria." *BCH* 64–65: 121–127.

———. 1961. "La destination de la Tholos de Delphes." *RHist*: 287–298.

Brague, R. 1982. *Du temps chez Platon et Aristote*. Paris.

Broneer, O. 1949. "Measurements and Refinements at the South Stoa at Corinth." *AJA* 53: 146–147.

———. 1954. *Corinth I 4. The South Stoa and its Roman Successors*. Princeton.

Brothers, C. 2008. *Michelangelo, Drawing, and the Invention of Architecture*. New Haven. Conn.

Brownson, C.D. 1981. "Euclid's Optics and its Compatibility with Linear Perspective." *Archive for History of Exact Sciences* 24: 165–194.

Brumbaugh, R.S. 1976. "Plato's Relation to the Arts and Crafts." *Facets of Plato's Philosophy*. Edited by W.H. Werkmeister, pp. 40–52. Assen.

Bryson, N. 1988. "The Gaze in the Expanded Field." In *Vision and Visuality: Discussions in Contemporary Culture* 2. Edited by H. Foster, pp. 87–114. Seattle.

Bundgaard, J.A. 1957. *Mnesicles, a Greek Architect at Work*. Copenhagen.

———. 1974. *The Excavation of the Athenian Akropolis 1882–1890*. Copenhagen.

———. 1976. *The Parthenon and the Mycenaean City on the Heights*. Copenhagen.

Burford, A. 1969. *The Greek Temple Builders at Epidauros*. Toronto.

Büsing, H. 1984. "Optische Korrekturen und Propyläen-Fronten." *JdI* 99 (1984): 27–73.

Cain, R.B. 2007. *The Socratic Method: Plato's Use of Philosophical Drama*. New York.

Calligas, P.G. 1996. "Archaeological Research on the Athenian Pnyx." In *The Pnyx in the History of Athens*. Proceedings of an International Colloquium Organised by the Finish Institute at Athens, 7–9 October, 1994. Edited by B. Forsén and G. Stanton, pp. 1–5. Helsinki.

Camp, J.M. 2001. *The Archaeology of Athens*. New Haven, Conn.

Carpinter 1970. *The Architects of the Parthenon*. Harmondsworth.

Castagnoli, F. 1971. *Orthogonal Town Planning in Antiquity*. Cambridge, Mass.

Cavarnos, C. 1971. "Plato's Critique of the Fine Arts." *Philosophia* 1: 296–314.

Cavvadias, P. 1891. *Fouilles d'Épidaure*. Vol. 1. Athens.

Charbonneaux, J. 1925. *Le sanctuaire d'Athéna Pronaia: La Tholos*. FdD II.4. Paris.

Choisy, A. 1865. "Note sur la courbure dissymétrique des degrees qui limitent au couchant la plate-forme du Parthénon." *Annuaire de l'Accadémie des Beaux Arts*: 57–60.

Christensen, J. 1999. "Vindicating Vitruvius on the Subject of Perspective." *JHS* 119: 161–166.

Cifarelli, M. 1998. "Gesture and Alterity in the Art of Ashurnasirpal II of Assyria." *ArtB* 80: 210–228.

Coarelli, F. 1982. "L'altare del tempio e la sua iscrizione." In *Gabii*, pp. 125–130.

———. 1987. *I santuari del Lazio in età repubblicana*. Rome.

———. 1988. *Il Foro Boario*. Rome.

———. 1995. *Da Pergamo a Roma: I Galati nella città degli Attalidi*. Rome.

———. 1997. *Il Campo Marzio. Dalle origini alla fine della Repubblica*. Rome.

Cook, J.M. and W.H. Plommer. 1966. *The Sanctuary of Hemithea at Kastabos*. Cambridge.

Congès, A.R. 1996. "Modalités pratiques de'impantation des cadastres romains: quelques aspects." *MEFRA* 108: 370–2.

Cornford, F.M. 1937. *Plato's Cosmology*. London.

Coulton, J.J. 1974. "Towards Understanding Greek Temple Design: The Stylobate and Intercolumniations." *Annual of the British School of Athens* 69: 61–86.

———. 1975. "Towards Understanding Greek Temple Design: General Considerations." *BSA* 70: 59–99.

———. 1976a. "The Meaning of Ἀναγραφεύς." *AJA* 80: 302–4.

———. 1976b. *The Architectural Development of the Greek Stoa*. Oxford.

———. 1977. *Ancient Greek Architects at Work: Problems of Structure and Design*. Ithaca, New York.

———. 1980. "Greek Architects and the Transmission of Design." In *Architecture et société de l'archaïsme grec à la fin de la République romaine*, pp. 453–468. Rome.

———. 1985. "Incomplete Preliminary Planning in Greek Architecture: Some New Evidence." In *Le dessin d'architecture dans les sociétés antiques*, pp. 103–121. Leiden.

Csapo, E. and M.C. Miller. 2007. "Introduction." In *The Origins of Theater in Ancient Greece and Beyond: From Ritual to Drama*. Edited by E. Csapo and M.C. Miller, pp. 1–40. Cambridge.

Davis, W.M. 1979. "Plato on Egyptian Art." *JEA* 65: 121–127.

———. 1989. *The Canonical Tradition in Ancient Egyptian Art*. Cambridge.

Davis, P.H. 1930. "Foundations of the Philonian Portico at Eleusis." *AJA* 34: 1–19.

Dearden, C.W. 1976. *The Stage of Aristophanes*. London.

De Jong, J.J. 1988. "The Temple of Athena Polias at Priene and the Temple of Hemithea at Kastabos." *BABesch* 63: 129–137.

———. 1989. "Greek Mathematics, Hellenistic Architecture and Vitruvius' De Architectura." In *Vitruvius*, pp. 100–113.

Demand, N. 1975. "Plato and the Painters." *Phoenix* 29: 1–20.

Derrida, J. 1985. "Des Tours de Babel." Translated by J.F. Graham. In *Difference in Translation*. Edited by J.F. Graham. Ithaca: 165–207.

De Zwarte, R. 1996. "Der ursprüngliche Entwurf für das Hephaisteion in Athen: Eine modulare architektonische Komposition des 5. Jhs. V. Chr." *BABesch* 71: 95–102.

De Waele, J.A. 1998. "Der klassische Tempel in Athen: Hephaisteion und Poseidontempel." *BABesch* 73: 83–94.

Dicks, D.R. 1970. *Early Greek Astronomy to Aristotle*. Ithaca.

Diels, H. and E. Schramm. 1919. *Philons Belopoiika*. Berlin.

Dinsmoor, W.B. 1941. *Observations on the Hephaisteion (Hesperia Suppl. 5)*. Baltimore.

———. 1950. *Architecture of Ancient Greece: An Account of Its Historic Development*, 3rd Edition. London.

———. 1961. "The Basis of Greek Temple Design." In *Atti del Settimo Congresso Internazionale di Archeologia Classica*, vol. 1, p. 364. Rome.

Dinsmoor, Jr., W.B. 1985. "Preliminary Planning of the Propylaia by Mnesikles." In *Le dessin d'architecture dans les sociétés antiques*, pp. 135–147. Leiden.

———. 2004. *The Propylaia to the Athenian Akropolis*. Volume II: The Classical Building. Princeton.

Di Teodoro, F.P. 1994. *Raffaello, Baldassar Castiglione e la Lettera a Leone X*. Bologna.

Dover, K.J. 1989. *Greek Homosexuality*. Cambridge, Mass.

Dunbar, N. 1995. *Aristophanes Birds*. Oxford.

Dürrbach, F. 1926-. *Inscriptions de Délos*. Paris.

Elsner, J. 2000. "Between Mimesis and Divine Power: Visuality in the Greco-Roman World." In *Visuality Before and Beyond the Renaissance*. Edited by R. Nelson, pp. 45–69. Cambridge.

———. 2007. *Roman Eyes: Visuality and Subjectivity in Art and Text*. Princeton.

Favro, D. "Reading the Augustan City." In *Narrative and Event in Ancient Art*. Edited by P. Holliday. Cambridge: 230–257.

———. 1996. *The Urban Image of Augustan Rome*. Cambridge.

———. 2006. "Virtual Reality Re-Creations and Academia." In *Imaging Ancient Rome: Documentation – Visualization – Imagination*. JRA Supplementary Series No. 61. Edited by Lothar Haselberger and John Humphrey, pp. 321–334. Portsmouth, Rhode Island.

Feng, G. and J. English. 1989. *Tao Te Ching*. New York.

Fensterbusch, C. 1964. *Vitruv. Zehn Bücher über Architektur*. Darmstadt.

Ferri, S. 1960. *Vitruvio (dai libri I-VII)*. Rome.

Fine, G. 2003. *Plato on Knowledge and Forms: Selected Essays*. Oxford.

Fletcher, B., and F.B. Fletcher. 1896. *A History of Architecture on the Comparative Method*. London.

Fleury, P., ed. 1986. *Vitruve de l'Architecture. Livre X. Collection des Universités de France*. Paris.

———., ed. 1990. *Vitruve de l'Architecture. Livre I. Collection des Universités de France*. Paris.

———. 1994. "Héron d'Alexandrie et Vitruve." In *Science et vie intellectuelle à Alexandrie*. Edited by G. Argoud, pp. 67–68. Saint-Étienne.

Frey, L. 1989. "Données architecturales et Hyothèses sur la mathématique pré-euclidienne. Le Partage Harmonique." In Vitruvius, pp. 90–99.

Frézouls, E. 1985. "Vitruve et le dessin d'architecture." In *Le dessin d'architecture dans les sociétés antiques: Actes du colloque de Strasbourg, 26–28 janvier 1984*. Travaux du Centre de Recherche sur le Proche-Orient et la Grèce Antiques 8. Edited by J.-F. Bommelaer, pp. 213–229. Strasbourg.

Fromel, C.L. 1994. "Reflections on the Early Architectural Drawings." In *The Renaissance from Brunelleschi to Michelangelo: The Representation of Architecture*. Edited by H.A. Millon and V. Magnago Lampugnani, pp. 101–120. New York.

Gadol, J. 1969. *Leon Battista Alberti: Universal Man of the Early Renaissance*. Chicago.

Galluzzi, P. 1996. "The Career of a Technologist." *Leonardo Da Vinci: Engineer and Architect*. Edited by P. Galluzzi, pp. 41–110. Montreal.

Geertman, H. 1989. "La progettazione architettonica in templi tardo-repubblicana e nel *De architectura*." In *Vitruvius*, pp. 154–177.

Gianfrotta, P.A., M. Polia, and O. Mazzacato. 1968–9. "Scavo nell'area del Teatro Argentina (1968–1969)." *BullCom* 81: 25–118.

Gjerstad, E. 1944. "Die Ursprungsgeschichte der Römischen Kaiserfora." *OpArch* 3: 40–72.

Gleason, K.L. 1990. "The Garden Portico of Pompey the Great." *Expedition* 32: 4–13.

Gnirs, A. 1915. *Pola. Ein Führer durch antiken Baudenkmäler und Sammlungen*. Vienna.

Goette, H. 1995. "Griechische Theaterbauten der Klassik – Forschungsstand und Fragestellungen." In *Studien zur Bühnendichtung und zum Theaterbau der Antike*. Studien zur Klassischen Philologie 93. Edited by E. Pöhlmann, pp. 9–48. Frankfurt am Main.

Goldhill, S. 1990. "The Great Dionysia and Civic Ideology. In *Nothing to Do With Dionysos: Athenian Drama in its Social Context*. Edited by J.J. Winkler and F. Zeitlin, pp. 97–121. Princeton.

———. 1998. "The Seductions of the Gaze: Socrates and his Girlfriends." In *Kosmos: Essays in Order, Conflict, and Community in Classical Athens*. Edited by P. Cartledge, P. Millett, and S. von Reden, pp. 105–124. Cambridge.

———. 2000. "Placing the Theater in the History of Vision." *Word and Image in Ancient Greece*. Edited by N. Keith Rutter and Brian A. Sparkes, pp. 161–182. Edinburgh.

Golvin, J.-C. 1988. *L'amphithéâtre romain*. Paris.

Goodyear, W.H. 1912. *Greek Refinements: Studies in Temperamental Architecture*. London.

Gouvretich, D. 2008. "Il bambino malato tra padre e medico: tre casi emblematici secondo Galeno (II-III secolo d.C.)." In *Medici e pazienti nell'antica Roma: La medicina romana a la domus 'del Chirugo' di Rimini*. Atti del Convengo internazionale Rimini, 12 giugno 2008. Edited by S. De Carolis and V. Pesaresi, pp. 45–56. Rimini.

Granger, F. 1931. *Vitruvius. On Architecture*. Loeb edition. Cambridge, Mass.

Griffin, M. 1994. "The Intellectual Developments of the Ciceronian Age." In *Cambridge Ancient History* IX: 689–728. Cambridge.

Gros, P. 1973. "Hermodoros et Vitruve." *MEFRA* 85: 151–153.

———. 1976a. "Nombres irrationnels et nombres parfaits chez Vitruve." *Mélanges de l'École française de Rome. Antiquité* 88: 669–104.

———. 1976b. "Les premières génerations d'architectes hellénistiques à Rome." In *L'Italie préromaine et la Rome républicaine. Mélanges offertes à Jacques Heurgon* vol. 1. Edited by in Raymond Bloch. Collection de l'École Française de Rome 27, pp. 387–409. Rome.

———. 1978. "Le dossier vitruvien d'Hermogénès." *MEFRA* 90: 687–704.

———. 1988. "Vitruve et les ordres." In *Les Traités d'architecture à la renaissance*. Colloque Tours. Edited by J. Guillaume, pp. 49–59. Paris.

———. 1990. *Vitruve de l'Architecture. Livre III*. Paris.

———. 1993. "Vitruviuo, la realtà architettonica e la progettazione de porte templari." *BABesch* 68: 209–245.

———. 1994. "La schema vitruvienne du theater latin et sa signification dans le système normative du *De architectura*." *RA*, 57–80.

———. 2006. *Vitruve et la tradition des traits d'architecture: fabrica et ratiocinatio*. Rome.

Gruben, G. 1963. "Das archaeische Didymaion." *JdI* 78: 78–177.

———. 1986. *Die Tempel der Griechen*, 4th ed. Munich.

———. 2001. *Griechische Tempel und Heiligtümer*. Munich.

Guichard, C.L. 2005. "Travels and Traversals in the Hellenistic Oracular Temples at Klaros and Didyma." Ph.D. diss., Columbia University.

Hahn, R. 2001. *Anaximander and the Architects: The Contributions of Egyptian and Greek Architectural Technologies to the Origins of Greek Philosophy*. Albany.

Halliwell, S. 2000. "Plato and Painting." *Word and Image in Ancient Greece*. Edited by N. Keith Rutter and B.A. Sparkes, pp. 99–118. Edinburgh.

Hansen, E. 1972. *The Attalids of Pergamon*. Cornell, New York.

Hanson, J.A. 1959. *Roman Theater-Temples*. Princeton.

Haselberger, L. 1980. "Werkzeichnungen am jüngeren Didymaion." *IstSMitt* 30: 191–215.

______. 1983a. "Bericht über die Arbeit am Jüngeren Apollontempel von Didyma." *IstMitt* 33 (1983): 90–123.

______. 1983b. "Die Bauzeichnungen des Apollontempels von Didyma." *Architectura* 13: 13–26.

______. 1985. "The Construction Plans for the Temple of Apollo at Didyma." *Scientific American*, December, 126–132.

______. 1989. "Die Zeichnungen in Vitruvs *De Architectura*." In *Vitruvius*, pp. 173–184.

______. 1991. "Aspekter der Bauzeichnungen von Didyma." *RA*, 99–113.

______. 1994. "Ein Giebelriss der Vorhalle des Pantheon: Die Werkrisse vor dem Augustusmausoleum." *RM* 101: 279–293.

______. 1997. "Architectural Likenesses: Models and Plans of Architecture in Classical Antiquity." *JRA* 10: 77–94.

______. 1999a. "Old Issues, New Research, Latest Discoveries: Curvature and Other Classical Refinements." In *Refinements*, pp. 1–68.

______. 1999b. "Curvature: The Evidence of Didyma." In *Refinements*, pp. 173–184.

______. 1999c. "Geometrie der Winde, Windige Geometrie: Städtebau nach Vitruv und Aristophanes." In *Stadt und Umland: Neue Ergebnisse der archäologischen Bau- und Siedlungsforschung*. Bauforschungskolloquium in Berlin vom 7. Bis 10 Mai 1997 veranstaltet vom Architektur-Referat des DAI. Discussionen zur archäologischen Bauforschung Band 7, pp. 90–100. Mainz.

______. 2005. "Bending the Truth: Curvature and Other Refinements of the Parthenon." In *Parthenon*, pp. 101–158.

Haselberger, L. and H. Seybold. 1991. "Seilkurve oder Ellipse? Zur Herstellung antiker Kurvaturen nach dem Zeugnis der didymeischen Kurvenkonstruktion." *AA*, 165–188.

Hauck, G. 1897. *Die Subjektive Perspektive und die Horizontalen Curvaturen des Dorischen Styls*. Stuttgart.

Heidegger, M. 1967. *What is a Thing?* Translated by W.B. Barton and Vera Deutsch. *Chicago*.

______. 1971. *Poetry. Language. Thought*. New York.

Heisel, J. 1993. *Antike Bauzeichnungen*. Darmstadt.

Hellman, M.-C. 1992. *Recherches sur le vocabulaire de l'architecture grecque, d'après les inscriptions de Délos*. Paris 1992.

______. 2002. *L'Architecture grecque, 1: Les principes de la construction*. Paris.

Helting, H. 2006. "Ἀλήθεια." In *Heidegger und die Antike*. Edited by H.-C. Günther and A. Rengakos, pp. 47–70. Munich.

Hemmingway, S. 2004. *The Horse and Jockey from Artemision: A Bronze Equestrian Monument of the Hellenistic Period*. Berkeley, California.

Herrmann, W. 1973. *The Theory of Claude Perrault*. London.

Hittorf, H. and L. Zanth. 1870. *Recueil des monuments de Ségeste et Sélinonte*. Paris.

Höcker, C. 2000. "Optical Refinements." In *Der Neue Pauly* 8: 1270.

Hoepfner, W. 1984. "Einführung: Masse – Proportionen – Zeichnungen." In *Bauplanung*, pp. 13–23.

______. 1990. "Bauten und Bedeutung des Hermogenes." In *Hermogenes*, pp. 1–64.

______. 1997. "Hermogenes und Epigonos: Pergamon zur Zeit Attalos I." *JdI* 112: 109–143.

Hoepfner, W. and E.-L. Schwandner. 1994. *Haus und Stadt im klassischen Griechenland*. Munich.

Holloway, R.R. 1966. "Architettura sacra e matematica pitagorica a Paestum." *Parola del Passato* 106: 64–68.

______. 1973. *A View of Greek Art*. Providence.

Horiuchi, K. 2004. In *New Measurements and Observations of the Treasury of Massaliotes, the Doric Treasury and the Tholos in the Sanctuary of Athena Pronaia at Delphi*. Edited by J. Ito, translated by J. Yoneoka, pp. 135–178. Hakozaki, Higashi-ku, Fukuoka, Japan.

Howe, T.N., and I. Rowland, trans. 1999. *Vitruvius. The Ten Books on Architecture*. Cambridge.

Humann, C., J. Kohte, and C. Watzinger. 1904. *Magnesia am Mäander: Bericht uber die Ergebnisse der Ausgrabungen der Jahre* 1891–1893. Berlin.

Huppert, A.C. 2009. "Envisioning New St. Peter's: Perspectival Drawings and the Process of Design." *JSAH* 68: 158–177.

Hurwit, J.M. 1999. *The Athenian Acropolis: History, Mythology, and Archaeology from the Neolithic Era to the Present*. Cambridge.

———. 2004. *The Acropolis in the Age of Pericles*. Cambridge.

———. 2005. "Space and Theme: The Setting of the Parthenon." In *Parthenon*, pp. 9–34.

Invernizzi, E. 2000. "Princípi geometrici del 'complesso sacro-istituzionale.'" In *Romolo, Remo, e la fondazione della città*. Edited by A. Caradini and R. Capelli, p. 296. Rome.

———. 2001. "Il 'complesso monumentale': osservazioni sulla natura geometrica dell'edificio." In *Tarquinia etrusca: una nuova storia*. Edited by A.M. Moretti, pp. 35–44. Rome.

Irlenborn, B. and G. Seubold. 2006. "Heidegger und die Antike Kunst." In *Heidegger und die Antike*. Edited by H.-C. Günther and A. Rengakos, pp. 285–303. Munich.

Isler, H.P. 1989. "Vitruvs Regeln und die erhaltenen Theaterbauten, Hellenistic Architecture and Vitruvius' De Architectura." In *Vitruvius*, pp. 141–153.

Ito, J. 2004. *New Measurements and Observations of the Treasury of Massaliotes, the Doric Treasury and the Tholos in the Sanctuary of Athena Pronaia at Delphi*. Translated by J. Yoneoka. Hakozaki, Higashi-ku, Fukuoka, Japan.

Janaway, C. 1995. *Images of Excellence : Plato's Critique of the Arts*. Oxford.

Jay, M. 1988. "Scopic Regimes of Modernity." In *Vision and Visuality: Discussions in Contemporary Culture* 2. Edited by H. Foster, pp. 3–23. Seattle.

Jeppesen, K. 1958. *Paradeigmata: Three Mid-Fourth Century Main Works of Hellenic Architecture Reconsidered*. Aarhus.

Jiménez, J.L. 1982. "Arquitectura." In *Gabii*, pp. 39–86.

Johansen, T.J. 2004. *Plato's Natural Philosophy: A Study of the Timaeus-Critias*. Cambridge.

Johnson, P.-A. 1994. *The Theory of Architecture: Concepts, Themes, & Practices*. New York.

Jones, H.L. 1960. *The Geography of Strabo*. Vol. VI. London.

Kallipolitis, V.G. 1972. "The Bronze Horse from Artemision." *AAA* 5: 425–426.

Käppel, L. 1989. "Das Theater von Epidauros. Die mathematische Grundidee des Gesamtentwurfs und ihr möglicher Sinn." *JdI* 104: 83–106.

Keuls, E. 1974. "Plato on Painting." *AJP* 95: 100–127.

———. 1978. *Plato and Greek Painting*. Leiden.

Kienast, H.J. 1977. "Der Tunnel des Eupalinos auf Samos." *Architectura*: 97–116.

———. 1984. "Planung und Ausführung des Tunnels des Eupalinos." In *Bauplanung*, pp. 104–110. Berlin.

———. 1985. "Der sog. Tempel D im Heraion von Samos." *AM* 100: 105–127.

———. 1986/7. "Der Tunnel des Eupalinos auf Samos." *Mannheimer Forum*: 179–271.

———. 1995. *Die Wasserleitung des Eupalinos auf Samos*. Mainz am Rhein.

———. 2004. "PARADEGMA. Das Vermächtnis des Eupalinos." *AM* 119: 67–90.

Kirk, G.S. and J.E. Raven. 1962. *The Presocratic Philosophers*. Cambridge.

Kirk, G.S., J. E. Raven, and M. Schofield. 1983. *The Presocratic Philosophers*. Cambridge.

Knell, H. 1973. "Vier attische Tempel klassischer Zeit." *AA*: 94–114.

Koch, H. 1955. *Studien zum Theseustempel in Athen*. Abhandlungen der sächsischen Akademie der Wissenschaften zu Leipzig 47. Berlin.

Koenigs, W. 1983. "Der Athenatempel von Priene: Bericht über die 1977–82 durgeführten Untersuchungen." *IstMitt* 33: 134–175.

_______. 1984. In *Bauplanung*, pp. 89–94.

_______. 1993. "Planung und Ausbau der Agora von Priene." *IstMitt* 43 (1993): 381–396.

_______. 1999. "The Temple of Athena Polias at Priene: Doric Architecture in the Guise of Ionic?" In *Refinements*, pp. 139–154.

Kokalakis, M. 1983. "The Iconography of Icarus." In *Concilium Eirene 16*. Edited by P. Olivia and A. Frolíková, pp. 2:25–2:30. Prague.

Kondaratos, S. 1994. "The Parthenon as Cultural Ideal: The Chronicle of its Emergence as a Supreme Monument of Eternal Glory." In *The Parthenon and Its Impact in Modern Times*. Edited by P. Tournikiotis, pp. 19–53. Athens.

Korres, M. 1994. "The Architecture of the Parthenon." In *The Parthenon and Its Impact in Modern Times*. Edited by P. Tournikiotis, pp. 54–97. Athens.

_______. 1996. "The Parthenon." In *The Parthenon: Architecture and Conservation*. Edited by M. Korres, G.A. Panetsos, and T. Seki, pp. 12–81. Athens.

_______. 1997. "Die Athena-Tempel auf der Akropolis." *Kult und Kultbauten auf der Akropolis*. Edited by W. Hoepfner, pp. 218–243. Berlin.

_______. 1999. "Refinements of Refinements." In *Refinements of Classical Architecture: Curvature*, pp. 79–104.

_______. 2001a. "Iktinos." In *Küstlerlexikon*, pp. 338–345.

_______. 2001b. "Kallikrates." In *Küstlerlexikon*, pp. 387–393.

_______. 2001c. "Karpion." In *Küstlerlexikon*, pp. 404–405.

Kreeb, M. 1990. "Hermogenes – Quellen und Datierungsprobleme." In *Hermogenes*, pp. 103–113.

Kyrieleis, H. 1976. "Bemerkungen zur Vorgeschichte der Kaiserfora." In *Hellenismus in Mittelitalien: Kolloquium in Gottingen vom 5. bis 9. Juni 1974*. Edited by P. Zanker, pp. 431–438. Göttingen.

Labrouste, H. 1877. *Temples de Paestum. Restaurations des monuments antiques par les architects pensionnaires de l'Académie de France a Rome*. Paris.

Lancaster, L. 2005. *Concrete Vaulted Construction in Imperial Rome: Innovations in Context*. Cambridge.

Lauter, H. 1986. *Die Architektur des Hellenismus*. Darmstadt.

Lawrence, A.W. 1983. *Greek Architecture*. New Haven, Conn.

Lewis, M.J.T. 2001. *Surveying Instruments of Greece and Rome*. Cambridge.

Liddel, H.G., R. Scott, and H.S. Jones. 1940. *Greek-English Lexicon*. 9th edition. Oxford.

Lindberg, D.C. 1976. *Theories of Vision from Al-Kindi to Kepler*. Chicago.

Lodge, R.C. 1953. *Plato's Theory of Art*. London.

Love, I.C. 1970. "A Preliminary Report of the Excavations at Knidos." *AJA* 74: 149–155.

Ludlow, T.W. 1882. "The Athenian Naval Arsenal of Philon." *AJP* 3: 317–328.

Lynch, K. 1960. *The Image of the City*. Cambridge, Mass.

MacDonald, W.L. 1982. *The Architecture of the Roman Empire. Volume I: An Introductory Study*. New Haven, Conn.

_______. 1986. *The Architecture of the Roman Empire. Volume II: An Urban Appraisal*. New Haven, Conn.

Maguire, J.P. 1964. "The Differentiation of Art in Plato's Aesthetics." *HSCP* 68: 400–402.

_______. 1965. "Beauty and the Fine Arts in Plato. Some Aporiae." *HSCP* 70: 171–193.

Marchetti-Longhi, G. 1932. *BullCom* 60: 253–346.

———. 1936. *BullCom* 64: 83–139.

———. 1956–58. *BullCom* 76: 45–118.

Marioni, A. 1996. "Leonardo's Impossible Machines." *Leonardo Da Vinci: Engineer and Architect*. Edited by P. Galluzzi, pp. 111–130. Montreal.

Marsden, E.W. 1971. *Greek and Roman Artillery. Technical Treatises*. Oxford.

Marstrand, V. 1922. *Arsenalet i Piraeus*. Copenhagen.

Martin, R. 1965. *Manuel d'architecture grecque*. Paris.

———. *Architecture et Urbanisme*. Paris.

McCredie, J.R. 1979. "Architects of the Parthenon." In *Studies in Classical Art and Archaeology: A Tribute to Peter Heinrich von Blanckenhagen*. Edited by G. Kipcke and M.B. Moore, pp. 69–73. Locust Valley, New Jersey.

McEwen, I.K. 1993. *Socrates' Ancestor: An Essay on Architectural Beginnings*. Cambridge, Mass.

———. 2003. *Vitruvius: Writing the Body of Architecture*. Cambridge, Mass.

Mertens, D. 1974. "Herstellung der Kurvatur am Tempel von Segesta." *RM* 81: 107–114.

———. 1984a. *Der Tempel von Segesta und die Dorische Tempelbaukunst des Griecheschen Westens in klassischer Zeit*. Mainz.

———. 1984b. "Zum klassischen Tempelentwurf." In *Bauplanung*, pp. 137–145.

———. 1993. *Der alte Heratempel in Paestum und die archaische Baukunst in Unteritalien*. Mainz.

———. 2006. *Städte und Baute der Westgriechen: Von der Kolonisationszeit bis zur Krise um 400 vor Christus*. Munich.

Millett, P. 1998. "Encounters in the Agora." In *Kosmos: Essays in Order, Conflict, and Community in Classical Athens*. Edited by P. Cartledge, P. Millett, and S. von Reden, pp. 203–228. Cambridge.

Millon, H.A. and V. Magnago Lampugnani, eds. 1994. *The Renaissance from Brunelleschi to Michelangelo: The Representation of Architecture*. New York.

Mogenet, J. 1950. *Autolycus de Pitane: Histoire du texte, suivie de l'édition critique des traités*. Louvain.

Mohr, R. 2005. *God and Forms in Plato*. New York.

Moore, K.B. 2010. "Ficino's Idea of Architecture: The 'Mind's-Eye View' in Quattrocento Architectural Drawings." *Renaissance Studies* 24.3: 332–352.

Morricone, L. 1950. "Scavi e ricerche a Coo (1935–1943)." *Bollettino d'arte* 35: 54–73.

Morris, S. 1992. *Daidalos and the Origins of Greek Art*. Princeton.

Müller, W. 1989. *Architekten in der Welt Antike*. Zurich.

———. 1990. *Grundlagen Gotischer Bautechnik*. Munich.

Mustafa Uz, D. 1990. "The Temple of Dionysos at Teos." In *Hermogenes*, pp. 35–80. Mainz.

Nabers, N. and S. Wiltshire. 1980. "The Athena Temple at Paestum and Pythagorean Theory." *GRBS* 21: 207–215.

Natorp, P. *Platonic Ideenlehre: Eine Einführung in den Idealismus*. Leipzig.

Nehamas, A. and P. Woodruff. 1995. *Plato: Phaedrus*. Indianapolis, Ind.

Nightingale, A.W. 2005. *Spectacles of Truth in Classical Greek Philosophy: Theoria in its Cultural Context*. Cambridge.

Nünnerich-Asmus, A. 1994. *Basilika und Portikus. Die Architektur der Säulenhallen als Ausdruck gewandelter Urbanität in später Republik und früher Kaiserzeit*. Cologne.

Oates, W.J. 1972. *Plato's View of Art*. New York.

Onians, J. 1979. *Art and Thought in the Hellenistic Age: The Greek World View*. London.

———. 1999. *Classical Art and the Cultures of Greece and Rome*. New Haven, Conn. and London.

Orlandos, A.K. 1976/7. *The Architecture of the Parthenon*. Vols. 1–2. Athens.

Orlandos, A.K., and I.N. Travlos. 1986. *Αεξιχὸν ἀρχαίων ἀρχιτεχτονιχῶν ὅρων. Βιβλιοθήχη τῆς ἐν Ἀθήναις Ἀρχαιολογιχῆς Ἑταιρείας* 94. Athens.

Packer, J. 2006. "A New Look at Pompey's Theater: History, Documentation, and New Excavations." *AJA* 110: 93–122.

———. 2007. "Looking Again at Pompey's Theater: The 2005 Excavation Season." *AJA* 111: 505–522.

Palagia, O. 2006. "Marble Carving Techniques." In *Greek Sculpture: Function, Materials, and Techniques in the Archaic and Classical Periods*. Edited by O. Palagia, pp. 243–279. Cambridge.

Panofsky, E. 1968. *Idea: A Concept in Art Theory*. New York.

———. 1975. *La Perspective Comme Forme Symbolique et Autres Essais*. Paris.

Parrot, A. 1948. *Tello*. Paris.

Penrose, F. 1851. *The Principles of Athenian Architecture*. London.

———. 1888. *The Principles of Athenian Architecture*. Revised 2nd ed. London.

Petit F. and J.A.K.E. de Waele. 1998. "Le Dessin du temple A d'Asklépios à Cos." *Pharos* 6: 59–68.

Petronotis, A. 1972. *Zum Problem der Bauzeichnungen bei den Griechen*. Athens.

Philipp, H. 1990. "Zu Polyklets Schrift 'Kanon.'" In *Der Bildbauer der griechischen Klassik*. Edited by H. Beck, P.C. Bol, and M. Bückling, pp. 135–155. Mainz.

Pickard-Cambridge, A.W. 1946. *The Theatre of Dionysus in Athens*. Oxford.

Pinto, J.A. 1976. "Origins and Development of the Ichnographic City Plan." *JSAH* 35.1: 35–50.

Polacco, L. 1990. *Il teatro di Dioniso Eleutereo ad Atene*. Rome.

Pollitt, J.J. 1972. *Art and Experience in Classical Greece*. Cambridge.

———. 1974. *The Ancient View of Greek Art*. New Haven, Conn.

———. 1986. *Art in the Hellenistic Age*. Cambridge.

———. 1995. "The Canon of Polykleitos and Other Canons." In *Polykleitos, The Doryphoros, and Tradition*. Edited by W. Moon, pp. 19–24. Madison, Wisconsin.

Puchner, M. 2010. *The Drama of Ideas: Platonic Provocations in Theater and Philosophy*. Oxford.

Radt, W. 1999. *Pergamon: Geschichte und Bauten einer antiken Metropole*. Darmstadt.

Rakob, F., and W.D. 1973. *Heilmeyer, Der Rundtempel am Tiber in Rom*. Maiz am Rhein.

Raven, J.E. 1951. "Polyclitus and Pythagoreanism." *CQ* 45: 147–152.

Richardson, Jr., L. 1992. *A New Topographical Dictionary of Ancient Rome*. Baltimore.

Richter, G. 1970. *Perspective in Greek and Roman Art*. London.

———. 1990. *Hellenistic Sculpture I: The Styles of ca. 331–200 B.C.* Madison, Wisconsin.

Riemann, H. 1959. Rev. of Bundgaard 1957. *Gnomon* 31: 309–319.

———. 1960. "Die Planung des Hephaisteions zu Athen." In *Θεωρία. Festschrift für W.-H. Schuchhardt*, 185–195. Baden-Baden.

Ringbom, S. 1965. "Plato on Images." *Theoria* 31: 86–109.

Rizzo, S. 2000. "Il progetto Fori Imperiali." In *Crypta Balbi – Fori Imperiali: Archeologia urbana a Roma e interventi di restauro nell'anno del Grande Giubileo*, edited by S. Baiani and M. Ghiraldi, pp. 62–78. Rome.

Robertson, D.S. *A Handbook of Greek and Roman Architecture*. 2nd ed. Cambridge.

Rocco, G. 2003. *Guida alla lettura degli ordini architettonici antichi. II, Lo ionico*. Naples.

Rodriguez-Almeida, E. 1981. *Forma urbis marmorea: aggiornamento generale 1980*. Vols 1–2. Rome.

———. 1991–2. "Diversi problemi connessi con la lastra n. 37 della *Forma Urbis Marmorea* e con la topografia *in circo e in campo*. *RendPontAcc* 64: 3–26.

Ros, K.E. 1994. "Vitruvius and the Design of the Carthage Theater." *AfrRom* 11: 907.

Rosand, D. 2002. *Drawing Acts: Studies in Graphic Expression and Representation*. Cambridge.

Rossi, C. 2004. *Architecture and Mathematics in Ancient Egypt*. Cambridge.

Rouveret, A. 1989. *Histoire et imaginaire de la peinture ancienne*. Paris.

Roux, G. 1961. *L'Architecture de l'Arrgolide aux 4me. et 3me. siècles av. J.-C.* Paris.

———. 1964. *Ancient Iraq*. London.

Rykwert, J., N. Leach, and R. Tavenor, trans. 1988. *Leon Battista Alberti. On the Art of Building in Ten Books*. Cambridge, Mass.

Saliou, C., ed. 1969. *Vitruve. De l'architecture. Livre V. Collection des Universités de France*. Paris.

Sapirstein, P. 2009. "How the Corinthians Manufactured Their First Roof Tiles." *Hesperia* 78: 195–229.

Sauron, G. 1987. "Le complexe pompéien du Champ de Mars: nouveauté urbanistique à finalité idéologique." In *L'Urbs. Espace urbain et histoire. Ier s. av. J.-C. – III s. ap. J.-C.*, pp. 457–473. Rome.

Scaglia, G. 1996. "A Typology of Leonardo's Mechanisms." In *Leonardo Da Vinci: Engineer and Architect*. Edited by P. Galluzzi, pp. 145–162. Montreal.

Schazmann, P. and R. Herzog. 1932. *Asklepieion: Baubeschreibung und Baugeschichte*. Ergebnisse der Deutschen Ausgrabungen und Forschungen, I. Berlin.

Schlikker, F.W. 1940. *Hellenistische Vorstellungen von der Schönheit des Bauwerks nach Vitruv*. Würzberg.

Schneider, L. and C. Höcker. 2001. *Die Akropolis von Athen*. Darmstadt.

Schneider, P. 1996. "Der Baubefund." In *Didyma III*. Edited by Klaus Tuchelt, pp. 1–116. Mainz am Rhein.

Schuhl, P.M. 1933. *Plato et l'art de son temps*. Paris.

Schulz, D. 1955. "Zum Kanon Polyklets." *Hermes* 83: 200–220.

Schweitzer, B. 1953a. *Plato und die bildende Künste der Griechen*. Tübingen.

———. 1953b. *Plato und die Kunst seiner Zeit*. Tübingen.

Scranton, R.L. 1974. "Vitruvius' Arts of Architecture." *Hesperia* 43: 494–499.

Sear, F. 1990. "Vitruvius and Roman Theater Design." *AJA* 94: 249–258.

———. 2006. *Roman Theaters: An Architectural Study*. Oxford.

Sennet, R. 1994. *Flesh and Stone: The Body and the City in Western Civilization*. London.

Senseney, J. 2007. "Idea and Visuality in Hellenistic Architecture: A Geometric Analysis of Temple A of the Asklepieion at Kos." *Hesperia* 76 (2007): 554–595.

———. 2009. "Vision and the Ordered Invisible: Geometry, Space, and Architecture in Hellenistic Sanctuaries of Asia Minor and Kos." In *Sacred Landscapes in Anatolia and Neighboring Regions*. Edited by C. Gates, J. Morin, and T. Zimmerman, pp. 35–46. Oxford.

———. forthcoming. "Measurement Systems, Surveying, and Models in Roman Architecture." In *The Blackwell Companion to Roman Architecture*. Edited by R. Ulrich and C. Quenemoen. Hoboken, New Jersey.

Senseney, J. and M. Finn. 2010. "The Book as Performance: Written Works, Theater, and Repositories in Classical Antiquity. *The International Journal of the Book* 7.3: 83–91.

Seybold, H. 1999. "Mathematical Basis for the Evaluation of Curvatures." In *Refinements*, pp. 105–112.

Sheppard, D.J. 2009. *Plato's Republic*. Bloomington, Ind.

Sherwin-White, S.M. 1978. *Ancient Cos: An Historical Study from the Dorian Settlement to the Imperial Period*. Göttingen.

Shoe, L.T. 1950. "Greek Moldings of Kos and Rhodes." *Hesperia* 19: 338–369.

Sjöqvist, E. 1954. "Kaisareion. A Study in Architectural Iconography." *OpRom* 13: 88–108.

Small, D.B. 1983. "Studies in Roman Theater Design." *AJA* 87: 55–68.

Smith, T.G. 2003. *Vitruvius on Architecture*. New York.

Soubiran, J., ed. 1969. *Vitruve. De l'architecture. Livre IX. Collection des Universités de France*. Paris.

Spencer, J.R., trans. 1966. *Leon Battista Alberti On Painting*. Revised edition. New Haven, Conn. and London.

Stevens, G.P. 1940. *The Setting of the Periclean Parthenon. Hesperia* Suppl. 3. Princeton.

_______. 1943. "The Curve of the North Stylobate of the Parthenon." *Hesperia* 12: 135–143.

_______. 1956. "The Volute of the Capital of the Temple of Athena at Priene Part II: A Machine for Drawing this Volute for Any Column between Twenty and Sixty Feet in Height." *MAAR* 24: 33–46.

Stewart, A. 1978. "The Canon of Polykleitos: A Question of Evidence." *JHS* 98: 122–131.

_______. 1990. *Greek Sculpture: An Exploration*. 2 vols. New Haven, Conn. and London.

_______. 1996. *Art, Desire, and the Body in Ancient Greece*. Cambridge.

_______. 2006. "Hellenistic Art: Two Dozen Innovations." *The Cambridge Companion to the Hellenistic World*. Edited by G.R. Bugh, pp. 158–185, Cambridge.

_______. 2008. *Classical Greece and the Birth of Western Art*. Cambridge.

Stewart, J.A. 1909. *Plato's Doctrine of Ideas*. Oxford.

Stillwell, R. ed. 1976. *The Princeton Encyclopedia of Classical Sites*. Princeton.

Strong, D. 1968. "The Administration of Public Building in Rome during the Late Republic and Early Empire." *BICS* 15 (1968): 97–109.

Stuart, J. and N. Revett. 1762 *Antiquities of Athens*. Vol. 1. London.

_______. 1787. *Antiquities of Athens*. Vol. 2. London.

_______. 1794. *Antiquities of Athens*. Vol. 3. London.

Summers, D. 2007. *Vision, Reflection, and Desire in Western Painting*. Durham, North Carolina.

Svenson-Evers, H. 1996. *Die griechischen Architekten archaischer und klassischer Zeit*. Frankfurt.

Tanner, J. 2006. *The Invention of Art History in Ancient Greece*. Cambridge.

Taplin, O. 1999. "Spreading the Word through Performance." In *Performance Culture and Athenian Democracy*. Edited by S. Goldhill and R. Osborne, pp. 33–57. Cambridge.

Taylor, R. 2003. *Roman Builders: A Study in Architectural Process*. Cambridge.

Thoenes, C. 1993. "Vitruv, Alberti, Sangallo: Zur Theorie der Architekturzeitung in der Renaissance." In *Hülle und Fülle: Festschrift für Tilman Buddensieg*. Edited by A. Beyer et al., pp. 565–584. Alfter.

Thompson, H.A. and R.E. Wycherly. 1972. *The Athenian Agora XIV – The Agora of Athens: The History, Shape and Uses of an Ancient City Center*. Princeton.

Tigler, P. 1963. *Die Architektur Theorie des Filarete*. Berlin.

Tomlinson, R.A. 1963. "The Doric Order: Hellenistic Critics and Criticism." *JHS* 83: 133–145.

_______. 1989. "Vitruvius and Hermogenes." In *Vitruvius*, pp. 71–75. Leiden.

Travlos, J. 1971. *Pictorial Dictionary of Ancient Athens*. London.

Trojani, M. 1974–1975. "Vitruvio e la genesi storica del teatro romano." *Atti ist. veneto di scienze, lettere e arti* 133: 463–477.

Ulrich, R.B. 1993. "Julius Caesar and the Creation of the Forum Iulium." *AJA* 97: 49–80.

Van Zanten, D. 1977. "Architectural Composition at the Ecole des Beaux-Arts from Charles Percier to Charles Garnier." In *The Architecture of the Ecole des Beaux-Arts*, pp. 112–324. Cambridge.

Voegelen, E. 2000. *Order and History Volume III: Plato and Aristotle*. Columbus, Ohio.

Von Gaertringen, F.H. 1906. *Inschriften von Priene*. Berlin.

Von Gerkan, A. 1921. *Das Theater von Priene: Als Einzelanlage und in seiner Bedeutung für das Hellenistisch Bühnenwesen*. Munich.

———. 1923. *Griechische Städteanlagen: Untersuchungen zur Entwicklung des Städtebaues im Altertum*. Berlin/Leipzig.

———. 1929. *Das Altar des Artemistempels in Magnesia am Mäander*. Berlin.

Von Gerkan, A. and W. Müller-Wiener. 1961. *Das Theater von Epidauros*. Stuttgart.

Von Steuben, H. 1973. *Der Kanon des Polyklet*. Mainz.

Waddell, G. 2002. "The Principle Design Methods for Greek Doric Temples and Their Modification for the Parthenon." *Architectural History* 45: 1–31.

Wallace-Hadrill, A. 2008. *Rome's Cultural Revolution*. Cambridge.

Ward-Perkins, J.B. 1981. *Roman Imperial Architecture*. New Haven, Conn.

Webster, T.B.L. 1952. "Plato and Aristotle as Critics of Greek Art." *Symbolae Osloenses* 29: 8–32.

———. 1956. *Greek Theatre Production*. London.

Wesenberg, B. 2001. "Vitruv und Leonardo in Salamis. "Vitruvs Poroportionsfigur' und die Metrologischen Reliefs." *JdI* 116: 357–380.

White, J. 1987. *The Birth and Rebirth of Pictorial Space*, 3rd ed. Cambridge, Mass.

White, J.W. 1912. *The Verse of Greek Comedy*. London.

Wiegand, T. and H. Schrader. 1904. *Priene: Ergebnisse der Ausgrabungen und Untersuchungen in den Jahren* 1895–1898. Berlin.

Wigley, M. 1993. *The Architecture of Deconstruction. Derrida's Haunt*. Cambridge, Mass.

Wilkinson, C. 1977. "The New Professionalism in the Renaissance." In *The Architect*. Edited by S. Kostoff, pp. 124–160. Oxford.

William Westfall, C. 1969. "Painting and the Liberal Arts: Alberti's View." *Journal of the History of Ideas* 30: 487–506.

Wilson Jones, M. 1993. "Designing Amphitheaters." *RM* 100: 391–442.

———. 1999. "The Practicalities of Roman Entasis." In *Refinements*, pp. 225–249. Philadelphia.

———. 2000a. *Principles of Roman Architecture*. New Haven, Conn.

———. 2000b. "Doric Measure and Architectural Design 1: The Evidence of the Relief from Salamis." *AJA* 104: 73–93.

———. 2001. "Doric Measure and Architectural Design 2: A Modular Reading of the Classical Temple." *AJA* 105: 675–713.

Winter, F.E. 1965. "Greek Theater Production: A Review Article." *Phoenix* 19: 99–110.

———. 1980. "Tradition and Innovation in Doric Design III: The Work of Iktinos." *AJA* 84: 399–416.

———. 1983. "The Stage of New Comedy." *Phoenix* 37: 199–204.

———. 2006. *Studies in Hellenistic Architecture*. Toronto.

Wittkower, R. 1953. "Brunelleschi and 'Proportion in Perspective.'" *JWarb* 16: 275–291.

Wünsche, R. 1979. "Der 'Gott aus dem Meer.'" *JdI* 94: 77–111.

Wycherly, R.E. 1937. "Aristophanes, *Birds*, 995–1009." *CQ* 31: 22–31.

———. 1942. "The Ionian Agora." *JHS* 62: 21–32.

———. 1962. *How the Greeks Built Cities. The Relationship of Architecture and Town Planning to Everyday Life in Ancient Greece*. 2nd ed. New York and London.

———. 1978. *The Stones of Athens*. Princeton.

Yegül, F.K. 1991. *Gentlemen of Instinct and Breeding: Architecture at the American Academy in Rome (1894–1940*). New York.

———. 1994. "Ephesus." In *Streets: Critical Perspectives on Public Space*. Edited by Z. Çelik, D. Favro, and R. Ingersoll, pp. 95–110. Berkeley, California.

Zambas, K. 2002. *Oi ekleptunseis ton kionon tou Parthenonos*. Athens.

Zeitlin, F. 1994. "The Artful Eye: Vision, Ecphrasis and Spectacle in Euripidean Theatre." In *Art and Text in Ancient Greek Culture*. Edited by S. Goldhill and R. Osborne, pp. 138–196. Cambridge.

INDEX

absolute beauty, 51, 52
aedificatio, 181
Aelian, 212
Agatharkhos, 63, 98, 135, 172, 213
Agrigento, 199
  Temple Concordia, 199
  Temple of Luco-Lacinia, 199
Aigina, 209
  Temple of Aphaia, 209, 214
Aiskhylos, 135, 213
Alberti, Leon Battista, 1, 169, 170, 172, 195, 206, 222
alethea. *See* truth
Alkmaion of Kroton, 63
Allegory of the Cave. *See* Plato
anagraphes, 32, 112, 200
analemma, 99, 181
analytic geometry, 45
Anaxagoras, 172, 213
Anaximander, 94, 136, 175, 183–185, 224
appearance, 51, 55, 151
araeostyle system of proportions, 160
architects, 1
  Greek, 8, 26, 32, 48–50, 58, 68, 80, 157, 158, 166, 167, 175, 183, 197, 209, 222, 223
  medieval, 169
  Renaissance, 1, 143, 169, 170, 172, 195
  Roman, 58, 83, 142, 153
architectural drawing, post-antique, 195
  medieval, 157, 195
  modern, 2, 3, 36, 44
  Renaissance, 157, 195
architectural form, 1
  Greek, 1, 39, 49, 151
  Roman, 1, 39
  Baroque, 21
  Byzantine, 39
  Mannerist, 21
architecture = *architectura*, 3, 8, 9, 17, 18, 25, 54, 58, 59, 64, 65, 68, 93, 99, 100, 138, 139, 141, 142, 145, 173, 175, 197
Aristophanes, 23, 61, 103
  Birds, 88, 95, 132, 161
Aristotle. *See* Aristotle, works of,
Aristotle, works of, 8
  De sensu, 63
    437b23–438a5, 63
  Mechanica, 224
  Metaphysics, 176
    1080b16, 176
    1090a21–1090a14, 176
    1092b26, 223
    1092b8, 222
    985b23–986b8, 176
  Nicomachean Ethics, 197
    6.4, 118
    6.4.4, 197
    6.4.5, 178
  Politics, 8
    1282a3, 8
Aristoxenos, 209
arithmetic, 52, 111, 143–145, 160, 176
armillary spheres, 207
astrolabes, 207
astronomical diagrams, 17, 22, 56, 58, 61–64, 73–75, 77, 98, 99, 135, 137, 145, 173
astronomy, 14, 17–19, 54, 56, 63, 93, 94, 113, 173, 179, 207, 225
Athena, 184
Athens, 3
  Academy, 144
  Agora, 28, 95, 221
  Akropolis, 3, 39
  City Dionysia, 87, 88, 134, 211
  Erechtheion, 21, 202
  Hephaisteion, 28, 34, 200, 221
  Khalkotheke, 29, 199
  Kolonos Agoraios, 28
  Orkhestra, 86, 95, 134
  Parthenon, 3, 21, 29, 39, 44, 48, 54, 69, 70, 108, 109, 115, 116, 129, 143, 156, 157, 196, 199, 200, 202, 203
  Pnyx, 29, 95, 132, 134, 212
  Propylaia, 29, 199, 202
  Sanctuary of Artemis Brauronia, 199
  Stoa of Attalos, 221
  Temple of Athena Polias, 214
  Temple of Dionysos, 95, 134
  Temple of Zeus Olympios, 213
  Theater of Dionysos, 21, 23, 86, 88, 95, 132, 134
Attalid dynasty, 144
Attalos I of Pergamon, 144, 146, 149
Augustus, 19
Aulus Gelleius, 209, 210
Ausonius, 196, 223
Autolykos of Pitane, 64
axial symmetry, 162, 169

beauty, 14, 17, 48, 51–53, 55, 56, 66, 112, 118, 179, 187
Benjamin, Walter, 55, 56
Benthem, Jeremy, 98
birth, 53
Bramante, Donato, 1

Broneer, Oscar, 214
Brunelleschi, Filippo, 3, 169, 170, 172, 195, 222
Brutus Callaicus, D. Iunius, 208

Caesar, Julius, 195
Canon. *See* Polykleitos
capitals, 32, 34
carpentry, 169
chronometry, 60, 94, 181, 186
Cicero, 195, 197, 200
circular buildings. *See* radially-designed buildings
cities. *See* urban planning
column fluting, 118, 133, 164, 173, 216, 217
columns, 34
commensuration, 10, 11, 51, 112, 113, 118, 131–132, 143, 146, 150, 151, 153, 164
compass and straightedge, 23, 27, 32, 33, 36, 49, 59, 64, 68, 69, 74, 75, 80, 92, 106, 108, 112, 114, 121, 132, 143, 145, 146, 157, 168, 170, 172, 216
concrete, Roman, 1, 18, 58, 59, 172, 196
construction process, 160, 161
Copernicus, 60, 206
copulation, 14, 16, 53
Corinthian order, 141, 165
corner triglyph problem, 42
correctness, 14, 51–53, 151
cosmic diagrams. *See* astronomical diagrams
cosmic mechanism, 57–58, 60–67, 75–77, 99, 137–138, 173–174, 185–187
cosmology, 55, 64, 205
Couton, J.J., 33, 50
craftsmanship, 3, 17, 44, 45, 50, 52, 54, 55, 61, 89, 101, 113, 173, 175, 179, 204, 205, 222
curvature, 29, 54, 108, 110, 220
curved ruler, 23, 89, 92, 132

Daidalos, 17, 56, 58, 60, 65, 99, 113, 138, 173, 176, 179, 180, 181, 184–186, 223, 224
dance, 52
decor (Latin term), 197
Delos, 83
  Theater, 83
Delphi, 69
  Siphnian Treasury, 214
  Tholos, sanctuary of Athena Pronaia, 69, 134, 141, 215
Demiourgos. *See* Plato
democracy, 95
Demokritos, 94, 172, 213
Derrida, Jacques, 55
Descartes, René, 12
desire, 14
diastyle system of proportions, 160
diathesis, 36, 47, 49, 50, 58, 142, 146–149, 151, 157, 158, 162, 164, 167, 197, 204
Didyma, 12, 14
  Anta Building, 34
  East Building, 34
  Temple of Apollo, 12, 14
    Archaic capitals, 116, 117
    blueprints on adyton walls, 40, 74, 104, 110, 114, 203
Diodoros Sikeliotes, 10, 197
dioptra, 61, 206
dispositio. *See diathesis*
Divided Line. *See* Plato
Divine Craftsman. *See* Plato
Doric order, 39, 156–158, 162, 203, 204
Dunbar, Nan, 89
Dying Gaul (statuary), 216
Dürer, Albrecht, 172

École des Beaux-Arts, 34, 196, 201
Egyptian architectural planning, 202
Egyptian art, 10
elevation drawing, 1, 8, 17, 36, 38, 48, 89, 100, 101, 142, 146, 195
engineering projects, 198
entablatures, 34
entasis, 34, 106, 113, 114
Ephesos, 64, 196
  Temple of Artemis, 64, 136, 177, 184, 213, 215
Epidauros, 70
  Theater, 80
  Tholos, 70, 134, 208
eros, 16
essence, 52, 55, 151
Etruscan planning, 207, 208
Euclid, 60, 63, 98, 136, 137, 206, 211
Eudoxos of Knidos, 66, 67, 69, 74, 137, 207
Euktemon, 94
Eupalinos, 198
Euripides, 224
eurythmia, 36, 52, 100, 142, 146, 147, 149, 151, 157, 158, 197
Eurytos, 176, 222
eustyle system of proportions, 160

Ferri, Silvio, 86
Ficino, Marsiglio, 9, 170, 222
fineness. *See* beauty
Fletcher, Banister, 3
Florence, 170
  Baptistry, 170, 172

Gabii, 164, 167
  Sanctuary of Juno, 164, 167, 221
Galen, 54, 177, 178, 215, 222, 224
Geminos of Rhodes, 209
geometry, 1, 14, 17, 18, 20, 22, 45, 47, 49–53, 55, 58, 63–65, 78, 110, 111, 113, 114, 132, 143–145, 148, 149, 151, 160, 162, 164, 165, 167, 172, 173, 176, 179
God, 52, 55, 150, 205
Goldhill, Simon, 102
Greek sculpture, 4, 8
  models and casts, 8
Greek theater. *See* Vitruvius (Marcus Vitruvius Pollio)
ground plans. *See* ichnography (ground plans)
Gruben, Gottfried, 116
Gudea, 202

Hadid, Zaha, 3
Halikarnassos, 215
  Mausoleum, 215
Haselberger, Lothar, 23, 74, 104, 108, 110, 114, 116, 128, 150
Heidegger, Martin, 10, 53, 54, 205
Herakleides Kritikos, 198
Hermodoros of Salamis, 166–168, 209
Hermogenes, 48, 49, 133, 150, 151, 153, 162, 164, 183, 202, 207
Hero of Alexandria, 89
Herodotos, 211
Himera, 199
  Large temple, 199
Hippodamos of Miletos, 93, 161
Hippolytus, 217, 224
Horse and jockey (from Cape Artemision), 5, 6, 14
hypographe, 150, 151, 154

Iamblichus, 204
ichnography (ground plans), 26, 34–44, 54–55, 58–59, 65, 68, 71–74, 79–86, 91, 100, 132–134, 143, 150–151, 153–168, 172–173, 175
idea (Greek term), 8, 9, 22, 44, 45, 47, 49, 50, 51, 53, 55, 56, 58, 62, 63, 88, 89, 112, 139, 142, 144, 151–153, 175, 176, 179, 181, 183, 184, 186, 197, 204
Idea of Beauty. *See* Plato
Idea of the Good. *See* Plato
Idealism, 9, 14, 15, 44, 45, 144, 149, 150, 151, 153, 170, 175, 176, 204
Ikaros, 185
Iktinos, 3, 39, 177, 183, 196, 200, 223
Iliad, 184
intelligence. *See* reason
Ionic order, 156, 157, 158, 161

Kallikrates, 177, 196, 223

Kant, Immanuel, 10, 44, 204
Karpion, 177, 196
Kastabos, 219
  Temple of Hemithea, 219
Khersiphron, 64, 136, 138, 177, 183–185
Knidos, 82
  Lower theater, 82, 84
knowledge, 53, 55, 56, 176, 205
Korinth, 214
  South Stoa, 214
  Temple of Apollo, 214
Kos, 45, 48
  Sanctuary of Aphrodite, 167, 222
  stoa, agora, 119, 129, 132
  Temple A, Asklepieion, 45, 48–50, 69, 74, 117, 162, 164, 172, 221
kouroi (statuary), 5

Labrouste, Henri, 201
Latin theater. *See* Vitruvius (Marcus Vitruvius Pollio)
Leonardo da Vinci, 143, 172, 186, 217, 225
light, 52, 53
linear perspective (*skenographia*), 1, 4, 8, 17, 36, 62, 63, 89, 98–101, 105, 134, 142, 146, 169, 172, 175, 195, 206
Lobachevsky, Nikolai Ivanovich, 61
Lucian, 196
Lynch, Kevin, 4

machines. *See* mechanics
Magnesia-on-the-Maeander, 36, 161
  Agora, 161, 162, 221
  Temple of Artemis Leukophryne, 36, 50, 69, 141, 150, 154, 156, 157, 161, 162, 221
  Temple of Zeus, 162
Manetti, Antonio, 170
masons, 34, 50, 160, 161, 169
measure, 51, 52, 110, 112, 222
mechanics, 58, 181–182, 184–187
Mertens, Dieter, 108
Mesopotamian architecture, 202
Metagenes, 64, 138, 177, 183–185
Meton of Athens, 88, 94–96, 132, 135
metrological analysis, 26, 204
Michelangelo Buonarroti, 172
mimesis, 44, 52, 53, 55, 56, 179, 182
mind. *See* reason
Minoan artistic form, 215, 216
Mirror Analogy. *See* Plato
Mnesikles, 199, 200
models. *See* paradeigmata
modern architecture, 3
modules, 114, 162, 164, 204, 217
musical theory, 18, 52, 56, 176, 179
Myron, 4, 196
  Diskobolos, 4, 196
Mytilene, 210
  Theater, 210

nature, 142, 144, 148, 149, 181
Naukratis, 202
Neoplatonism, 9, 170
Nero, 173
Nietzsche, Friedrich, 11
Nightingale, Andrea Wilson, 11
noumena, 44
nous. *See* reason
number, 26, 45, 47, 49, 50, 54–56, 70, 110, 111, 113, 114, 116, 118, 142–147, 160, 162, 164, 176, 177, 179, 182, 183, 186, 199

oikonomia, 100, 197
Olympia, 120
  Temple of Hera, 120
optical theory, Greek, 4, 17, 18, 22, 62, 96, 136, 150, 206
order, 142, 144, 146, 148, 162, 175
ordinatio. *See* *taxis*
orreries, 207
Ovid, 224

Paestum, 45
  Temple of Athena, 45, 48, 49, 176, 199
  Temple of Hera I, 199, 213
  Temple of Hera II, 201
painting. *See* linear perspective (*skenographia*)
Palmanova, Italy, 95
Panopticon, 98
paradeigmata, 10, 16, 17, 32, 34, 51, 54–56, 58, 61, 101, 112, 119, 160, 176, 179, 180, 182, 186, 200, 201, 223
parapegmata, 94
Parmenides, 207
parti, 2, 196
patrons, 34
Pausanias, 80, 196, 198, 210, 223
Pergamon, 80, 119, 129, 132, 144
  Theater, 80
Perrault, Claude, 199
Persian War, 39
Phaistos, 211
Pheidias, 8, 39, 200
Philon Mechanikos, 54, 150, 151, 156, 178, 200, 205, 215
Philon of Eleusis, 201
philosophy, Greek, 4, 22, 55, 68, 149, 150, 186
Piero della Francesca, 172
Piraeus, 201
  Arsenal, 201
Place de l'Etoile, Paris, 95
Plato. *See also* Plato, works of
  Allegory of the Cave, 10–12, 16
  Divided Line, 102, 176, 205
  Divine Craftsman, 17, 52, 98, 99, 181, 204
  Idea of Beauty, 53
  Idea of the Good, 44, 52, 53, 205
  Mirror Analogy, 170, 171, 222
  World Soul, 207
Plato, works of, 8
  Charmides, 197
    170c, 197
  Critias, 95, 212
    115c, 95
  Gorgias, 197
    451c, 225
    506e, 52
    514b, 197
  Laws, 95, 212
    778c, 95
    821e–822a., 207
    966e–967c, 207
  Meno, 51
    82b-86c, 51, 151
  Phaedrus, 14
    247a, 207
    250b–d, 53
    251a, 14
    251b, 53, 63
    252d, 14
    254b, 14
    254b–c, 14
  Philebus, 51
    27a, 205
    27b, 205
    51c, 51
    51c–d, 51, 52
    55e, 205
    56b–c, 54, 56, 112, 129, 170, 179, 181
    64e, 51, 222
  Republic, 10, 23, 56, 58, 60, 65
    346d, 197
    400e–402b, 52
    444d, 52
    444e, 52, 222
    472d, 102
    484c, 101
    490b, 14, 53, 102, 111
    500e–501c, 101
    507b, 52
    507c, 52
    507e–508a, 53
    508b, 53, 63
    508e, 44, 53, 102
    509d–511e, 102, 176
    510a–d, 205
    514–517, 10
    517b–c, 44, 102
    517c, 53
    519b, 16, 52
    524c, 52, 183

  Plato, works of (*cont.*)
    525c, 52, 111
    526e, 11, 52, 65, 111
    527a–b, 65
    527b, 11, 14, 51, 65, 102, 111
    529a, 14
    529b, 65, 111
    529c–e, 17, 57, 99
    529c–530a, 184
    529c–530c, 65
    529d, 179, 182, 225
    529e, 113, 198
    529e–530a, 102, 180
    530d–531c, 56, 113
    531c, 56
    533d, 16, 205
    540a, 101
    596b, 17, 44, 45, 52
    596d–e, 170
    596e–597e, 204
    597e, 179
    598b–c, 170
  Sophist, 10
    235d, 10, 51, 180
    235d–236e, 10, 55, 112, 170
    235e, 10, 56, 177
  Statesman, 8, 212
    259e, 50
    261c, 8
    284a–b, 205
  Symposium, 9, 88
    210e–212e, 205
  Timaeus, 16, 56, 58, 60, 65, 204
    19b–c, 101
    27d–28a, 102, 113
    28a, 205
    28c–29a, 17, 102, 186
    38c, 182
    45b, 52
    45b–c, 16, 63
    45c, 53
    47a, 52
    47a–b, 176, 182, 207
    48e–49a, 66, 102, 113
    53e–54a, 51, 52
    68e, 223
    90c–d, 207
Pliny the Elder, 197, 209
Plutarch, 196, 198, 210, 212, 223
poetry, 52, 179, 206
Pola (Pula, Croatia), 195
  on-side drawing on amphitheater, 195
Pollitt, J.J., 10, 14, 15
Polykleitos, 54, 80, 117, 138, 142, 151, 156, 177, 179, 211, 223
Polykles, 197
Pompeii, 215
  Central Baths, 215
Porphyry, 204
porticoes. *See* stoas
Poseidonia. *See* Paestum
posotes, 36
Priene, 36, 161
  Temple of Athena Polias, 36, 49, 50, 150, 153, 154, 156–158, 160, 219
Propertius, 210
proportion, 26–28, 31, 143
protractor. *See* curved ruler
Psamtik, 202
pseudodipteral type, 156
Ptolemy, 68, 137
pycnostyle system of proportions, 160
Pythagoras, 45
Pythagoreanism, 45, 50, 51, 55, 56, 63, 117, 151, 152, 176, 177, 179, 204, 222, 223
Pytheos, 18, 36, 47, 49, 133, 153, 162, 172, 183

radial protraction, 118, 132
radially-designed buildings, 69, 73, 78, 93, 105, 138, 145, 172
Raphael (Raffaello Sanzio da Urbino), 195
Raptopoulos, Sotiris, 215
reason, 51, 53, 66, 176, 179, 185, 186
reception, ancient, 21, 198
refinements, 29, 31, 51, 54, 150, 200
Rhoikos, 177, 183
Rimini, 209
  House of the Surgeon, 209
Rome, 23, 25, 162
  Campus Martius, 23, 78
  Circus Flamminius, 23, 78
  Curia Pompei, 79, 210
  Domus Aurea, 172, 173
  Forum Augustum, 79
  Forum Iulium, 23
  Forum of Trajan, 168
  Imperial fora, 23, 168
  Markets of Trajan, 79
  New St. Peter's, 195
  Palazzo Pio Righetti, 79
  Pantheon, 59, 145, 173
  Porticus Metelli, 167
  Porticus Pompeianae, 79, 209, 210
  Prati region, 95
  Round Temple, 71, 141, 208
  Temple B, Largo Argentina, 208
  Temple of Mars in Circo, 208
  Temple of Venus Victrix, 79, 209, 210
  Theater of Marcellus, 82
  Theater of Pompey, 78
round buildings. *See* radially-designed buildings
rule of the second column, 41

sacrifice, ritual of, 134
Samos, 34, 177, 198
  Temple D, Heraion, 34
  Temple of Hera, 177
  tunnel of Eupalinos, 198
Sardis, 119, 120
  Temple of Artemis, 119, 120
scamilli inpares, 108
science, greek, 68
sculpture, Greek, 51, 54–56, 143, 179, 180, 223
section drawing, 195
seeing. *See* vision
Segesta, 27
  Unfinished temple, 27, 114, 116, 129, 199
Selinut, 199
  Temple A, 199
Seybold, Hans, 109, 110, 114
single-axis protraction, 104, 108, 116, 118
six-petal rosette, 74, 75, 128
Skopas the Younger, 208
sleeping hermaphrodite (sculpture), 6, 8, 14, 197
Sokrates, 14, 16, 51, 103, 205
Sophokles, 135, 211
soul, 9, 10, 12, 52, 53, 205
Sparta, 86
species (Latin term). *See* *idea* (Greek term)
spectacle. *See* vision
spirituality, 9–11, 16
Stevens, G.P.,
stoas, 33, 164, 167, 169, 221
Strabo, 143, 144, 149, 196, 198, 223
Suetonius, 173, 195, 210
Suicide Gaul (statuary), 217
sun, 52, 205
sundials. *See* analemma
symmetria. *See* commensuration
syngraphai, 32, 34, 38, 160, 181, 201
Syracuse, 199
  Temple of Athena, 199
systyle system of proportions, 160

Tao Te Ching, 15, 16
Tarquinia, 207
  Sanctuary complex, 207, 208
taxis, 36, 47, 49, 50, 52, 58, 100, 142, 146–149, 151, 157, 158, 162, 164, 167, 197, 204
techne, 129, 205
teleion, 45
teleology, 224
temples, 33
Teos, 207
  Temple of Dionysos, 150, 207
Tertulian, 210
tetraktys, 45, 47, 49
thauma, 12
theatai, 97, 102, 213

theaters, 4, 19, 73, 74, 95, 98
  in Greek culture, 4
Theodoros, 177, 183
Theodoros of Phokaia, 69, 134
theoria, 16, 17, 19, 87, 88, 95, 98, 102, 103, 138, 198
theoroi, 61, 87, 88, 97, 103
Thucydides, 211
translation, 55, 56
triglyphs, 32, 34, 203, 220
truth, 50, 51, 53–55, 176, 205
T-square, 35, 36, 74

urban armatures, 4
urban planning, 61, 78, 161, 162

Van der Rohe, Mies, 3
vehicles, 186, 187, 225
Virtual Reality, 196
vision, 3, 5–7, 9, 16, 17, 19, 38, 52–53, 56, 60–65, 87–88, 96–103, 108, 111, 134–139, 172, 182–183, 185
Vitruvian Man. *See* Vitruvius (Marcus Vitruvius Pollio)
Vitruvius (Marcus Vitruvius Pollio), 1, 10, 11, 18, 22, 44, 45, 49, 58, 97, 98, 100, 101, 142, 146, 151, 183, 195, 199
  Greek theater, 82, 86, 94, 95, 136, 172, 211
  Latin theater, 73, 75, 80, 94, 95
  Vitruvian Man, 23, 143, 144, 146, 151, 170, 218
De architectura, 8
  10.1.4, 184, 224
  10.2.11–12, 185
  10.2.13, 187
  1.1.12, 183
  1.1.13, 143
  1.1.2, 146
  1.1.2–4, 36
  1.1.4, 111, 146
  1.2.1–4, 146
  1.2.3–4, 147
  1.2.4, 146–148
  1.3.1, 181
  3. 5.14, 106, 215
  3.1.1–4, 142
  3.1.2, 149
  3.1.3, 143
  3.1.4, 149
  3.1.5, 204
  3.3.13, 106
  3.3.1–8, 34
  3.4.5, 108, 150, 200
  3.5.14, 121
  3.5.9, 200
  3.praef.2, 143
  4.3.2, 42, 220
  4.8.2, 70, 134
  5.6.1–4, 73
  5.7.1–2, 82, 92
  5.9.4, 108
  6.1.1, 151
  6.2.2, 150, 200
  6.2.2–5, 200
  6.3.11, 200
  7.praef. 12, 69, 133, 196
  7.praef.11, 135, 172
  7.praef.12–17, 224
  9.1.2–3, 64
  9.1.3–5, 74
  9.1.5, 75, 95
  1.2.1–9, 8
  1.2.2, 8, 9, 143, 146–148, 197, 202
  1.1.16, 18

Wallace-Hadrill, Andrew, 142
war, 222
weaving, 184
White, John, 62
whitened boards for drawing (λεύχωμα), 40, 104
Wilson Jones, Mark, 27
World Soul. *See* Plato

Xenophon, 213

Yegül, Fikret, 119

zodiac, 66, 68, 75, 77, 136